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Middle-Upper Cambrian Transition Faunas of North America

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MIDDLE-UPPER CAMBRIAN TRANSITION FAUNAS OF NORTH AMERICA

By B. F. HOWELL AND DONALD DUNCAN

During the preparation of a correlation chart of the Cambrian formations of North America several perplexing problems have arisen, among them the problem of the faunal sequence from Middle to Upper Cambrian and the problem of the position of the Middle-Upper Cambrian boundary.

Faunas which partially fill the gap between the youngest previously recognized Middle and the oldest previously recognized Upper Cambrian faunas have recently been discovered and partially described by Raymond, Resser and Howell.[1] These faunas were found in widely separated localities in North America. They include both new genera and previously known genera whose ranges have been extended as a result of these discoveries.

This paper will present some facts about these faunas and their relationships, and will serve as an explanation of the faunal arrangement and correlations in certain parts of the North American Cambrian correlation chart.

The uppermost Middle Cambrian fauna in the British Cambrian sections of Wales and England is the *Paradoxides davidis* fauna. This fauna is found also in southeastern Newfoundland. A Paradoxidian fauna of somewhat later age occurs just above the *Paradoxides davidis* fauna in Scandinavia, where it is known as the *Paradoxides forchhammeri* fauna. A similar fauna is widely distributed in Siberia, and is probably present in southeastern Newfoundland. The "*Kochaspis*" *upis* fauna of the Rocky Mountains may be of about the same age. A still younger Paradoxidian fauna from the St. Albans formation of Vermont has been described by the senior author as the *Centropleura vermontensis* fauna.[2] Some of its members resemble species of the

[1] Raymond, P. E., *Upper Cambrian and Lower Ordovician Trilobita and Ostracoda from Vermont*, Geol. Soc. Amer., Bull., Vol. 48, pp. 1079–1146. 1937.
Resser, C. E., *Cambrian System (Restricted) of the Southern Appalachians*, Geol. Soc. Amer., Special Papers, No. 15. 1938.
Howell, B. F., *Cambrian Centropleura vermontensis Fauna of Northwestern Vermont*, Geol. Soc. Amer., Bull., Vol. 48, pp. 1147–1210. 1937.

[2] Howell, B. F., *idem.*

Paradoxides forchhammeri fauna, but a number of its genera have never been found in any fauna containing *Paradoxides forchhammeri* or any other species of *Paradoxides.* This fauna is proved by its Paradoxidian species, however, to be of Medial, not Late, Cambrian age.

Above the *Centropleura vermontensis* beds in northwestern Vermont lie strata, named by Schuchert[3] the Hungerford Formation, which contain a fauna that is obviously related to the Late Cambrian *Cedaria* fauna of the Mississippi Valley and the Rocky Mountains, but which includes some genera that occur also in the underlying *Centropleura* fauna. A comparison of the *Centropleura vermontensis* fauna with a fauna secured by the senior author from the lower part of the Hungerford Formation and with the faunas described by Raymond from the Upper Cambrian beds above the *Centropleura* beds in northwestern Vermont, reveals that a number of the trilobites in the *Centropleura vermontensis* beds are related to species in the strata which lie above them. As an example may be cited *Albansia convexa* Howell, which is probably closely related to "*Onchonotus*" *eminens* Raymond, a species found in the Upper Cambrian Hungerford beds.

Further evidence of the very late Medial Cambrian age of the *Centropleura vermontensis* fauna is found in the fact that the fauna contains species of the following genera known elsewhere in Late Cambrian or latest Medial Cambrian rocks, or genera which are closely related to them. Examples of such species are *Agraulos perkinsi* Howell, 1937, which is a Kingstonid, herewith tentatively referred to *Ankoura* Resser, a genus found in the Upper Cambrian Nolichucky Formation of Tennessee, and in Upper Cambrian beds in Wyoming and Montana; *Solenopleura franklinensis* Howell, 1937, which is nearly related to *Armonia*, a genus found in Alabama and Montana in beds close to the line between the Middle and Upper Cambrian; and *Solenopleura rara* Howell, 1937, which is apparently closely related to, and possibly actually referable to, *Blountiella*, a genus of the Upper Cambrian *Cedaria* and *Crepicephalus* zones of the southern Appalachians and Montana.

The similarity of these *Centropleura* fauna species to others which are members of *Cedaria* faunas indicates that the *Cedaria* faunas appeared not very long after the *Centropleura* faunas died out.

In 1935, other late Medial and early Late Cambrian faunas were discovered by Deiss in central Montana. The sections in which these faunas occurred were described by him in 1936.[4] His later studies of the fossils disclosed that the collection from his locality 41 A, whose beds form part of the upper portion of the "Park formation" in the Big Snowy Mountains, contained both Middle and Upper Cambrian trilobites. In 1937, therefore, he and the junior author made additional collections from the upper "Park formation" at that locality. In the 25 feet of beds which had yielded the earlier made collection, four faunules were distinguished. Of these, the fau-

[3] Schuchert, Charles, *Cambrian and Ordovician of Northwestern Vermont*, Geol. Soc. Amer. Bull., Vol. 48, p. 1047. 1937.

[4] Deiss, Charles, *Revision of Type Cambrian Formations and Sections of Montana and Yellowstone National Park*, Geol. Soc. Amer. Bull., Vol. 47, pp. 1257-1342. 1936.

nule from the lowest beds (locality 41-3a) is definitely Middle Cambrian. It will be described by Norman Denson. The three succeeding faunules (41-3b, 41-3c, 41-3d) are probably all referable to the Upper Cambrian. They will be described by Howell, Lochman and Duncan. The following table shows the relationships of the faunules.

Beds of "locality 41-3" upper part of "Park formation"	41-3d. *Arapahoia*, a characteristic genus of the *Cedaria* faunas.	Undoubted Upper Cambrian
	41-3c.- Early *Cedaria*-like trilobites.	
Predominantly green shale with intercalated gray limestone lenses, 6" to 30" in diameter.	41-3b.--Few early *Cedaria*-like trilobites, *Perioura*, *Piedmontia*, *Albansia?*, *Deissella?* (cf. *Hysteropleura*), *Micragraulos?*.	Probably Upper Cambrian
	41-3a.-*Deissella* faunule, younger than the "*Kochaspis*" *upis* fauna of western Montana.	Believed to be Middle Cambrian

The trilobites in the lowest faunule listed above (the *Deissella* faunule of division 3a) include species of the new genus *Deissella* (described on a later page), *Ehmaniella?*, and *Eldoradia?* together with Agnostia which are either early members of the genus *Homagnostus* or members of some closely related genus. Of these species, those referred tentatively to *Ehmaniella* and *Eldoradia* seem to be closely related to Middle Cambrian species of somewhat older faunas, and *Deissella* may have been derived from *Bolaspis* or a *Bolaspis*-like form of earlier Medial Cambrian age. However, this faunule cannot be correlated exactly with any previously described Middle Cambrian fauna, although it resembles the Middle Cambrian *Centropleura vermontensis* fauna of Vermont.

The next overlying faunule, that of division 3b, contains the following trilobites: a *Deissella*-like genus, perhaps a descendant of *Deissella;* an *Albansia*-like genus, perhaps a descendant of *Albansia*, a *Piedmontia;* a *Micragraulos*-like genus, perhaps a descendant of *Micragraulos;* a *Homagnostus*-like Agnostian, perhaps ancestral to *Homagnostus; Perioura;* and a *Cedaria*-like genus, perhaps ancestral to *Cedaria* but having a pygidium which resembles that of *Weeksina unispina* (Walcott). The species of the *Cedaria*-like genus and of the *Homagnostus*-like genus in this faunule are closely allied to species found in Upper Cambrian beds elsewhere in the United States. The species of the *Deissella*-like genus, the *Albansia*-like genus and the *Micragraulos*-like genus are closely related to species occurring in the late Medial Cambrian *Centropleura vermontensis* fauna of Vermont. *Piedmontia* and *Perioura* occur in beds of the Conasauga Formation which may be of either Medial or Late Cambrian age. The faunule thus includes both Medial Cambrian and Late Cambrian genera.

The faunule from the next overlying division (3c) contains species of the following trilobite genera: *Weeksina?*, *Deissella?* or *Hysteropleura?*, and an undescribed genus that is closely related to, and probably ancestral to, *Cedaria*. Of these genera, the *Cedaria*-like one and the *Weeksina?* are known to occur in Upper Cambrian beds of the *Cedaria* Zone elsewhere in North America. A species, as yet undescribed, that is probably referable to *Deissella*

(although it shows points of resemblance to *Hysteropleura*), has also been discovered in the Upper Cambrian of Vermont.

In the collection from the next overlying beds (3d) two well known trilobite genera, *Arapahoia* and *Cedaria* (or a closely related genus), have been found. The known range of *Arapahoia* coincides very closely with that of true *Cedaria*. The questionable *Cedaria* of locality 41-3d has been found in other sections in Montana in typical *Cedaria* faunas.

The study of the successive faunules in the upper part of the "Park formation" of the Big Snowy Mountains has thus afforded evidence that the deposition of the beds containing them went on almost without any significant break. There may be a small hiatus between the beds containing the faunules of divisions 3a and 3b; but this break could not have involved the interruption of deposition for any long period of time, and the faunas must have followed one another in an almost unbroken succession.

A comparison of the *Centropleura vermontensis* fauna of northwestern Vermont with the faunules of the upper part of the "Park formation" of the Big Snowy Mountains of Montana indicates that the upper "Park" faunules of divisions 3a and 3b are of approximately the same age as the St. Albans fauna, which is late Medial Cambrian. On the other hand, the beds of divisions 3c and 3d contain such characteristically Upper Cambrian species that they, like the beds which overlie those holding the *Centropleura vermontensis* fauna in Vermont, are unquestionably of Late Cambrian age.

Of the two faunules, 3a and 3b, that of 3a is most like the late Medial Cambrian *Centropleura vermontensis* fauna, and it is so much like that fauna that it should undoubtedly be considered to be of Medial (although perhaps of latest Medial) Cambrian age. The faunule of division 3b is not predominantly either Medial Cambrian or Late Cambrian in aspect, and it is probably intermediate in age between the latest Medial Cambrian and the earliest Late Cambrian faunas that have hitherto been recognized. We have therefore had to decide whether to look upon it as a Middle Cambrian faunule or whether to assign it a place above the Middle-Upper Cambrian boundary. We consider that it should be assigned to the Upper Cambrian because two of its seven most characteristic genera of trilobites—*Cedaria?* and the *Homagnostus*-like Agnostian—are known from beds elsewhere that are definitely of Late Cambrian age; three—the *Deissella*-like genus, the *Albansia*-like genus and the *Micragraulos*-like genus—look as though they might be descendants of *Deissella*, *Albansia*, and *Micragraulos*, which are genera of the *Centropleura vermontensis* fauna; and the other two—*Piedmontia* and *Perinura*—have been reported from the Conasauga Formation of Alabama (which is at least in part Upper Cambrian) and so must have come from a horizon very close to, if not above, the boundary between the Middle and Upper Cambrian.

Thus, we have, in these beds of locality 41-3, in the Big Snowy Mountains of central Montana, and in formations in northwestern Vermont and beds of equivalent age in the southern Appalachians, faunas which fill the gap between the latest previously recognized Medial Cambrian faunas and the oldest previously known Late Cambrian faunas. And so well do these faunas fill this gap that we can now look upon the succession of faunas in this part of the

Cambrian column as practically complete. The following faunas must have lived, the one after the other, in chronological order (although not all of them in a single region), and must have ranged in time from the late Medial Cambrian to the early Late Cambrian, making a nearly or quite unbroken faunal-chronological chain from the one epoch to the other.

Cedaria fauna of 41–3d Faunule with *Cedaria*-like trilobites of 41–3c	Late Cambrian
Perioura-Piedmontia faunule of 41–3b	Probably Late Cambrian
Deissella faunule of 41–3a *Centropleura vermontensis* fauna *Paradoxides forchhammeri* fauna *Paradoxides davidis* fauna	Middle Cambrian

In order to make available to the reader further information concerning some of the species and genera to which reference has been made in this paper, some figures of them, and notes concerning them, are presented herewith.

ALBANSIA Howell, 1937

Albansia pusilla Howell, 1937

Albansia pusilla Howell, Geol. Soc. Amer. Bull., vol. 48, p. 1178, pl. 4, figs. 20, 23, 24. 1937.

Remarks: This is a species of the *Centropleura vermontensis* fauna of the late Medial Cambrian St. Albans Formation of northwestern Vermont. The holotype cranidium is re-illustrated to show its similarities to that of *Albansia? montanensis*, new species. The occipital ring is much enlarged but does not have so much of a spine as the original description indicates. The rim is transversely striated with three or four faint, anastomosing lines.

Albansia? montanensis, new species.

Fig. 3.

Description: Cranidium small, strongly convex, trapezoidal in outline. Glabella large, rounded in front, strongly elevated above the fixed cheeks, unfurrowed. Occipital ring thickened medially, unspined. Occipital furrow broad, shallow medially, deeper laterally. Dorsal furrow narrow, deep laterally. Brim very narrow, composed of a narrow upturned rim and a deep transverse furrow which joins the dorsal furrow in front of the glabella. Fixed cheeks slightly less than half the width of the glabella, moderately convex. Eyes of medium size, crescentiform, situated about opposite middle of the glabella. Postero-lateral limbs of fixed cheeks wide, marked by a rather deep and broad posterior furrow. Facial sutures converge somewhat in front of the eyes and curve outward and backward behind the eyes. Surface of cranidium smooth.

Free cheek, thorax and pygidium unknown.

Remarks: This species is known from several cranidia. It differs from *Albansia pusilla* in possessing a less thickened rim, and less thickened occipital

ring. It is probably an *Albansia*, but its exact generic reference must remain in doubt until the species is better known.

Types: Holotype is no. T1614 in paleontological collection Montana State University; paratypes no. T1615 in same collection and no. 52193 in paleontological collection of Princeton University.

Horizon and locality: Beds of locality 41-3b, in the upper part of the "Park formation" (probably earliest Late Cambrian), at the head of Swimming Woman Creek, on the southern side of Great House Peak, in the Big Snowy Mountains, central Montana.

ARAPAHOIA Miller, 1936

Arapahoia snowiensis, new species

Fig. 10.

Description: Cranidium moderately convex, smooth. Glabella very large, tapered anteriorly, rounded in front, elevated above rest of the cranidium, marked by three faint glabellar depressions or furrows, which show only when the specimen is coated with ammonium chloride. Occipital furrow broad and shallow, anteriorly arcuate. Occipital ring prolonged into a short spine. Dorsal furrow better developed than in most described species of the genus. Brim narrow, slightly convex, equally divided into flattened rim and preglabellar areas by a faint transverse furrow. Fixed cheeks very narrow in front of eyes. Eye lobe of medium size, crescentiform. Postero-lateral limb of fixed cheek short and wide, marked by a broad furrow near the posterior edge. Facial suture intramarginal nearly to the median line in front, rounds antero-lateral angles of cranidium, extends backward and slightly inward to, and then around, eye lobe, then curves laterally and posteriorly to the posterior margin of the cephalon. Surface of cranidium smooth, except for minutely granulose areas surrounding the glabellar furrows.

Free cheek and thorax unknown.

Pygidium semi-circular in outline, strongly convex. Axis highly elevated above pleural lobes, extending almost full length of pygidium. Anterior two axial furrows strong, third axial furrow weak. Pleural lobes moderately convex, marked by three pleural furrows. Border narrow, merging anteriorly with the post-axial ridge. Surface of pygidium smooth.

Remarks: Arapahoia snowiensis, new species, is most similar to *Arapahoia spatulata* Miller, 1936, but differs from that species in possessing a larger glabella and correspondingly narrower brim.

Types: Holotype is no. T1624 in the paleontologic collection of Montana State University; paratypes are no. T1625 in the same collection, and nos. 52202 and 52203 in the paleontological collection of Princeton University.

Horizon and locality: The species is known from several cranidia and a single associated pygidium from the upper part of the "Park formation" (early Upper Cambrian, *Cedaria* zone) from the beds of locality 41-3d, near the head of Swimming Woman Creek, on the southern side of Great House Peak, Big Snowy Mountains, central Montana.

DEISSELLA, new genus

Diagnosis: Cranidium wide at base, tapered rapidly anteriorly. Glabella approximately two thirds the length of the cranidium, narrow, conical, truncate in front, strongly convex. Two distinct glabellar furrows, directed backward at an angle of approximately 45°, are distinguishable on the inner surface of the test. Occipital furrow narrow and deep laterally, broader and shallower medially. Occipital ring broad, convex, unspined in adult forms. Dorsal furrow very deep laterally, distinct but much shallower in front of glabella. Brim concave, divided into a convex, strongly upturned rim and a slightly convex preglabellar area by a broad, deep transverse furrow; whole brim bent steeply downward at sides. Free cheeks very wide, convex, highly elevated above dorsal furrow, so that the eyes are about level with the top of the glabella. Eyes of medium size; ocular ridge well developed, directed laterally from antero-lateral angle of the dorsal furrow, curved posteriorly to the eye lobes. Postero lateral limbs of free cheeks long, wide, directed posteriorly and downward at the distal ends, marked by distinct, broad furrow. Facial sutures converge rapidly in front of the eyes, probably outlining the rather straight anterior edge of the cranidium. Surface of cranidium smooth.

Associated free cheek of medium size, comparatively flat, with highly elevated ocular platform. Border narrow. Genal spine directed diagonally outward.

Pygidium moderately convex, ovate in outline. Axis less than one-third total width of pygidium, moderately convex and elevated above pleural lobes, extended almost to posterior edge of pygidium, divided into six segments. Pleural lobes relatively flat, marked by five furrows. Border narrow. Surface of pygidium smooth.

Genotype: Ptychoparia? convexa Howell, Geol. Soc. Amer. Bull., vol. 48, pp. 1182 1183, pl. 5, figs. 3 6, 12.

Remarks: Deissella is similar to *Hysteropleura* Raymond, 1937, in many respects. The glabella of *Deissella* is, however, proportionately larger, the eyes are larger, and the preglabellar area is slightly convex, whereas that of *Hysteropleura* appears to be concave. *Deissella* also bears some resemblance to *Bolaspis* and *Acrocephalops*, but differs from these genera in several features of the cranidium which need not be discussed here. Relationships with all three of these genera are, however, suggested by the characters which the genus has in common with them.

A species of *Deissella* occurs in the collections from the beds of locality 41-3a in the upper part of the "Park formation," in the Big Snowy Mountains, Montana. It closely resembles the genotype.

Deissella convexa (Howell), 1937

Fig. 5.

Ptychoparia? convexa Howell, 1937, Geol. Soc. Amer. Bull., vol. 48, p. 1183, pl. 5, figs. 3-6, 12.

The species is one of the more common trilobites of the *Centropleura vermontensis* fauna of the St. Albans Formation of Vermont.

The holotype cranidium, no. 40003 in the paleontological collection of Princeton University, is from the St. Albans Formation, 1 mile southeast of Swanton Junction, Franklin County, Vermont.

HOMAGNOSTUS Howell, 1935

Homagnostus? lochmanae, new species

Figs. 7–9.

Description: Cephalon with dorsal and transverse furrows clearly developed. Posterior portion of glabella highly elevated in uncrushed specimens, anterior portion bluntly rounded, frontal lobe distinct, basal lobes poorly developed. Medial furrow very faint and with the anterior portion not incised in some specimens. Border moderately upturned.

Thorax of ordinary, lobed Agnostian form.

Pygidium strongly convex in uncrushed specimens. Axis extended nearly to posterior border, highly convex, with two faint axial furrows. Posterior lobe slightly enlarged, rounded posteriorly. Dorsal furrow strong, merged with marginal furrow posteriorly. Border well developed, wide, extended at posterior corners of pygidium into spines which are long for a *Homagnostus*. The axis in immature specimens is narrower than in adults.

Remarks: Homagnostus? lochmanae is doubtfully referred to *Homagnostus* because the medial furrow of the cephalon is so weakly developed and the axis of the pygidium, especially in young specimens, is so narrow. The pygidium differs from that of *H. obesus*, the genotype, in possessing a narrower and less globose axis, weaker axial furrows, and longer spines on the border. *H. lochmanae* is tentatively considered to be an early form of *Homagnostus*.

Types: Holotype is no. T1621 in the paleontological collection of Montana State University; paratypes are T1622 and T1623 in the same collection, and nos. 52199, 52200 and 52201 in the paleontological collection of Princeton University.

Horizon and locality: The species is common in the beds of locality 41–3b (probably earliest Late Cambrian) in the upper part of the "Park formation" at the head of Swimming Woman Creek, on the southern side of Great House Peak, Big Snowy Mountains, central Montana.

MICRAGRAULOS Howell, 1937

Micragraulos franklini Howell, 1937

Fig. 6.

Micragraulos franklini Howell, Geol. Soc. Amer. Bull., vol. 48, p. 1188, pl. 5, figs. 16, 20, 21, 25.

Micragraulos franklini Howell is the genotype of its genus. The holotype cranidium was collected from the St. Albans Formation, 1 mile southeast of Swanton Junction, Franklin County, Vermont. A species very similar to *M. franklini* occurs in the collections from the beds of locality 41–3b, in the upper part of the "Park formation" in the Big Snowy Mountains, central Montana.

PIEDMONTIA Resser, 1938

Piedmontia cordillerae, new species

Fig. 4.

Description: Cranidium gently convex. Glabella moderately convex, apparently without glabellar furrows. Occipital furrow strongly developed at sides, shallower medially. Occipital ring less elevated than posterior part of glabella, prolonged into large, posteriorly directed spine. Dorsal furrow deep, entire. Brim approximately one fourth length of cranidium, subequally divided into convex preglabellar area and slightly upturned rim by a broad transverse furrow. Fixed cheeks approximately one-half width of glabella, slightly elevated above dorsal furrow, flattened or gently convex. Eye lobe very gently curved. Middle of eye situated anterior to a line drawn transversely through middle of glabella. Ocular ridge broad, distinct, curved postero-laterally from the antero-lateral portion of the dorsal furrow. Postero-lateral limb of free cheek rather long, moderately wide. Facial sutures diverge moderately in front of eyes, strongly back of eyes. Surface of cranidium smooth.

Pygidium, thorax, and free cheeks unknown.

Remarks: *Piedmontia cordillerae* differs from *P. magnispina* Resser, 1938, the genotype, in possessing an occipital furrow and in having a less strongly upturned rim. The holotype cranidium is preserved in shale, however, and some flattening may have occurred during compaction of the shale.

Types: Holotype is no. T1620 in the paleontological collection of Montana State University; paratype is no. 52198 in the paleontological collection of Princeton University.

Horizon and locality: The species is rare in the beds of locality 41–3b, in the upper part of the "Park formation" (probably earliest Late Cambrian) at the head of Swimming Woman Creek, on the southern side of Great House Peak, in the Big Snowy Mountains, central Montana.

PERIOURA Resser, 1938

Perioura lata, new species

Figs. 11–13.

Description: Cranidium relatively flat. Glabella gently convex, more than three-fourths the length of the cranidium, tapered anteriorly, with straight side and rounded frontal outline. No glabellar furrows. Occipital furrow rather broad and shallow. Occipital ring gently convex, moderately wide. Dorsal furrow strong, entire. Brim narrow, subequally divided into flattened preglabellar area and gently convex rim by an almost straight transverse furrow. Fixed cheeks flattened, more than half the width of the glabella. Eye lobe crescentiform, approximately one-fourth the length of the glabella, situated opposite the middle of the glabella. Palpebral furrow broad, shallow. Postero-lateral limbs subtriangular in outline, marked by broad, rather deep marginal furrows. Facial suture intramarginal at least along antero-lateral edge of rim, rounds antero-lateral edge of cranidium, extends postero-medi-

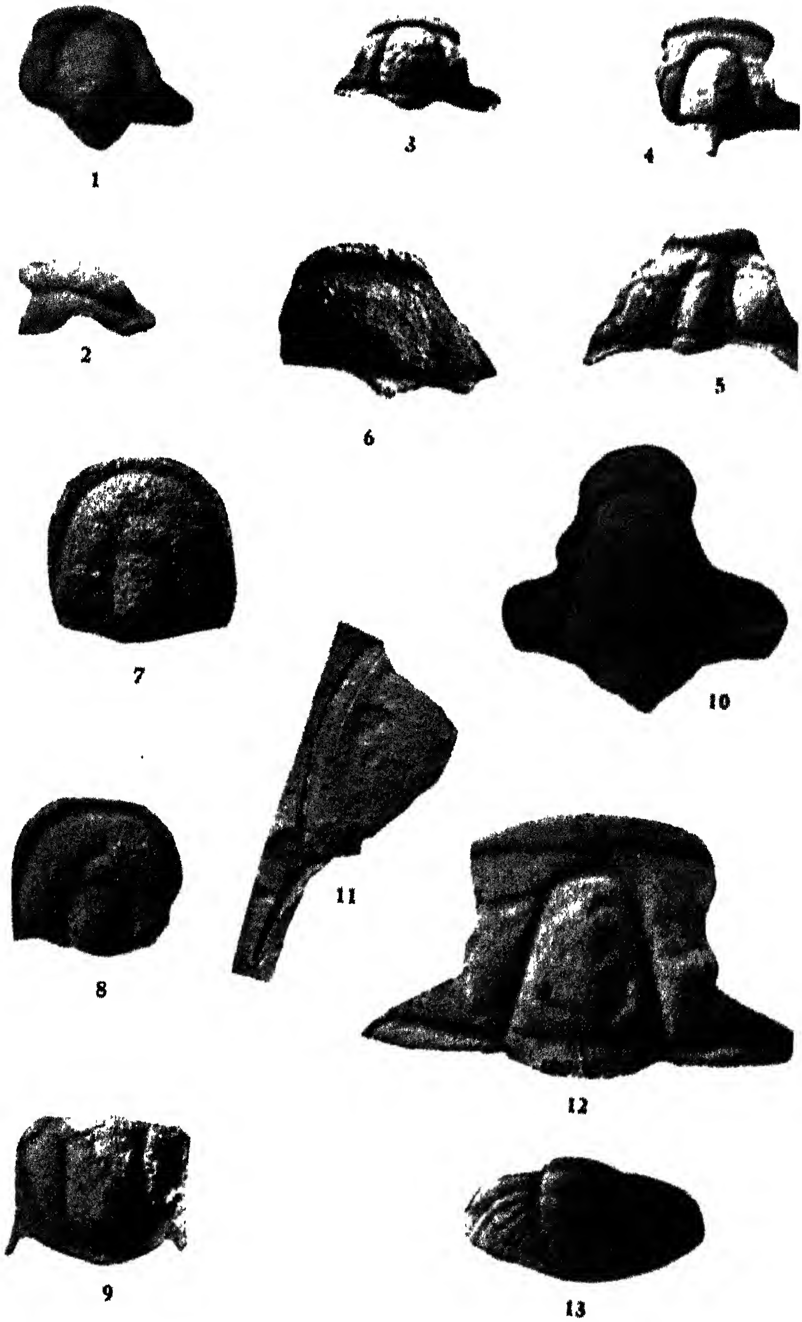
ally to, then around, eye-lobe, thence nearly straight postero-laterally toward the genal angle, then turns abruptly to a postero-medial course to cut the posterior edge of the cephalon well in from the genal spine.

Free cheek large, inner surface ornamented with numerous anastomosing ridges radiating from the eye region to the border. Border at anterior portion of cheek much narrower than at postero-lateral angle. Genal spine large, projected postero-laterally at approximately 45° angle to long axis of body. Doublure of free cheek is approximately the same width as border, but does not vary in width.

Pygidium ovate in outline, flattened convex. Axis almost one-third width of, and nearly full length of, pygidium, moderately convex, with two or three distinct segments and a terminal portion; slightly tapered posteriorly. Dorsal furrow broad but deep laterally, interrupted posteriorly by a post-axial elevation extending to posterior margin of pygidium. Pleural lobes possess four distinct furrows extending to border; anterior furrows strong. Lateral border widened, slightly thickened and upturned. Border narrowed posteriorly and merged with post-axial elevation from axis.

Remarks: *Perioura lata* differs from *P. masoni* Resser, 1938, in possessing wider fixed cheeks and a narrower preglabellar area. The glabella or *P. lata* is narrower and more strongly tapered than in either *P. typicalis* Resser, 1938, or *P. masoni*.

Types: Holotype is no. T1616 in the paleontological collection of Montana University. Paratypes are nos. T1617, T1618, and T1619 in the same collection, and nos. 52194–52197 in the paleontologic collection of Princeton University.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Explanation of Plate

Figs. 1, 2: *Albansia pusilla* Howell. Holotype cranidium. x 8. No. 40117, Princeton Univ. St. Albans Formation, late Medial Cambrian; northwestern Vermont.

Fig. 3: *Albansia? montanensis*, n. sp. Holotype cranidium. x 4. No. T1615, Montana State Univ. Upper part of "Park formation," loc. 41–3b, probably earliest Late Cambrian; head of Swimming Woman Creek, Big Snowy Mts., Montana.

Fig. 4: *Piedmontia cordillerae*, n. sp. Holotype cranidium. x 4. No. T1620, Montana State Univ. Same loc. as fig. 3.

Fig. 5: *Deissella convexa* (Howell). Holotype cranidium. x 2. No. 40003, Princeton Univ. St. Albans Formation, late Medial Cambrian, northwestern Vermont.

Fig. 6: *Micragraulos franklini* Howell. Holotype cranidium. x 4. No. 40135, Princeton Univ. St. Albans Formation, late Medial Cambrian, northwestern Vermont.

Figs. 7–9: *Homagnostus? lochmanae*, n. sp. Holotype (fig. 8) and paratype (fig. 7) cephala and paratype pygidium (fig. 9). x 8. Nos. T1621 (fig. 8), T1622 (fig. 9), and T1623 (fig. 7), Montana State Univ. Same loc. as fig. 3.

Fig. 10: *Arapahoia snowiensis*, n. sp. Holotype. x 4. No. T1624, Montana State Univ. Upper part of "Park formation," loc. 41–3d, *Cedaria* Zone, early Late Cambrian; head of Swimming Woman Creek, Big Snowy Mts., Montana.

Figs. 11–13: *Perioura lata*, n. sp. Holotype (fig. 12) cranidium and paratype free cheek (fig. 11), and pygidium (fig. 13). x 2. Nos. T1616 (fig. 12), T1618 (fig. 11), and T1617 (fig. 13), Montana State Univ. Same loc. as fig. 3.

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A SYNOPSIS OF FOUR LECTURES ON THE MAKING AND MIXING OF HUMAN RACES

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THE FORMATION OF PRIMARY RACES IN THE HUMAN SPECIES

The physical facts of race have been confused with ignorant fancies and the whole matter of psychological and cultural correlates has been left for exploitation by unscrupulous and fanatical laymen who have not hesitated to utilize its vast potentialities for political and social injustice.

I stand firmly upon the platform of racial equality, since the range and mean of individual capacity within the several human races has never been proved to differ significantly. Each has, in all probability, its own array of points of strength, offset by weaknesses, and these points do not always coincide in all of the different races. Add them all together in any single race and I am afraid that it amounts to zero, or, in other words, it comes out even. Thus all races are equal. The only way of beating this racial equality game is to mix races and then to select for survival those individuals in whom fortuitously or by genetic law the strong qualities of the parent races are combined, and eliminate the rest.

A race is a large body of mankind the members of which possess similar combinations of physical variations which they owe to their common descent. Race is therefore a physical classification based upon hereditary anatomical features. The term carries no necessary implications of language, nationality, or culture. Racial resemblances are therefore nothing other than family resemblances spread more thinly over very much larger groups and with the degrees of blood relationship correspondingly attenuated.

Mankind has differentiated into races through the long-continued interaction of several natural forces, some of which are organic and others extra-organic. The first of the intrinsic race-forming forces is variation. Neither

asexual nor sexual reproduction operates with mechanical precision to give birth to identical organic forms. Therefore variation is the result of germinal instability, chance combination of genes, and erratic reproductive performance. Some of this variation is doubtless environmentally actuated, but probably a good deal of it is due to sheer germinal cussedness.

When the organism in development or during maturity actually modifies itself in response to environmental stimuli, direct or indirect, we call this process adaptation. This process of adaptation can be identified only in the comparatively few cases where a simple and definite environmental cause produces a constant and discernible organic effect which can be experimentally checked and verified.

Another potent race-making factor is geographical isolation. Of course this is not in any sense a force, either environmental or organic; it is merely a fact of position. Undoubtedly, geographical isolation in a uniform environment which requires physical adaptations, together with subsequent inbreeding, forms the most potent race-making complex of organic and extra-organic conditions. These are the agencies of certain physical differentiation. A related group of physically similar individuals becomes a race as soon as its numerical strength is sufficient to baffle the reckoning of blood relationship.

There remain but two race-making factors. These are genetic dominance and hybridization.

Since race is a broad measure of blood relationship, it is necessary to select as the physical criteria of race characteristics which are inherited and which persist relatively unchanged throughout the life of the individual. This condition rules out of consideration bodily features which can be radically altered during one's life span through function and nutrition. It follows that the most important features of the human organism have a very narrow range of variation because of the strict requirements of their function, and that inherited characters which are broadly differentiated in distinct groups of men so that they can be used readily as a basis of racial classification are, for the most part, functionally non-adaptive, trivial, and generally indifferent features which have little or no survival value for the species.

The physical anthropologist uses combinations of measured characters and morphological features—the latter as standardized and objectified as possible. The more intricate the combination of metric and morphological characters utilized, the finer is the group classification. Combinations of the variations of three or four different characters are enough to establish the broad classification of relationship which we call race. Over-elaboration in the use of multiple criteria results in the delimiting of intra-racial groups or closer degrees of blood-relationship.

In the array of modern types of man certain primary divisions may be recognized which have a somewhat broader and more general significance than racial groupings.

White Division

The first of these great divisions may be called White or Caucasoid. Both terms are misnomers—the former because the range of skin pigmentation in

this division is from dark brown through fish-belly white to raw-beef color; the latter because this division has not diffused from the Caucasus as a centre of development, but almost certainly from an area somewhat farther east. This diversified White division of mankind is united by the common possession of a few physical characters which are mostly generalized rather than specialized.

Australoid

Within this White group by far the most primitive race is the archaic Australoid which probably reached the antipodal continent before the end of the Pleistocene or glacial period over an islanded route which presented fewer wide gaps than it does at present. These aboriginal Australians are reminiscent of fossil types of man in their huge brow ridges, low and receding foreheads, protrusive jaws, feeble chins, large palates and big teeth. They have exaggeratedly broad and fleshy-tipped noses adorning extremely short broad faces, and their skins vary from a medium red-brown to a dark chocolate color (in exposed parts). The Australian race is probably not, as some think, an unmixed remnant of the men of the Old Stone Age, but is rather an archaic White type which has been modified in a slightly Negroid direction by mixture with its predecessors in the Australian continent—the now extinct Tasmanians.

Ainu

Much less primitive than the Australians, but still representative of the more archaic elements in the White division of mankind, is the Ainu race, domiciled in the islands to the north of Japan, the outlying remnant of an ancient population stratum which probably extended at one time across Siberia into Europe. They are usually called the "Hairy Ainu" because the men can boast of the most luxuriant beards and the furriest bodies to be found in the human species. The Ainu are definitely related to the Australians, but they represent a more highly evolved and relatively unpigmented type, without suspicion of Negrito admixture. Strains of Ainu race blood are to be found in Eastern Europe, especially in Russia, where the novelist Tolstoi was a notable double for a typical Ainu.

Mediterranean

Apart from these two archaic and vestigial stocks, the most ancient and far-flung White race is that which is usually called Mediterranean. This race is fundamentally very dark brunet white, or light brown in skin color, has black or dark brown hair and dark eyes, and is dolichocephalic or long-headed.

This basic Eur-African, brunet, long-headed race must be divided into several subraces. The first of these is the Classic Mediterranean type, as exemplified in ancient and modern Egyptians, many Arabs, Berbers, Italians, Spaniards, and some Britons. A somewhat more primitive variety or subrace may be distinguished as the Crude Mediterranean type. The bony contours are more rugged and angular, the brow ridges larger, the face shorter and squarer, with more protruding cheek bones and jaw angles, the nose broader

and lower with slight tendency toward concavity of the bridge, the chin less prominent but squarer and often cleft, beard and body hair somewhat less sparse.

Another Mediterranean subrace may be designated as the Arabo-Mediterranean. It shows most of the gracility of the Classic type, but tends to be slightly taller, with longer face and very high-bridged, narrow nose, usually beaked or aquiline, with thin and depressed tip. Finally we have the Atlanto-Mediterranean subrace of this great stock, which is much taller and rather more heavily built.

Iranian Plateau

Closely allied with these last two varieties of the Mediterranean race, the Arabo-Mediterranean and Atlanto-Mediterranean subraces, is another physical type which perhaps should receive separate racial classification, on a parity with the great Mediterranean race. This type, recently distinguished by Dr. Henry Field's researches in Iran and Iraq, may be called provisionally the Iranian Plateau race. It now seems probable that most of the convex and hooked noses, which are so common in the Near East and have diffused from that area, are due to this Iranian plateau stock which has passed on these features in many mixtures with other racial groups.

Nordic

The Nordic race is certainly a depigmented offshoot from the basic long-headed Mediterranean stock. It deserves separate racial classification only because its blond hair (ash or golden), its pure blue or gray eyes, and its pink or ruddy skin indicate that it is the result of a radical mutation toward suppression of pigment, fixed by a long process of inbreeding and selection in an isolated area.

Alpine

The basic differentiation of the White division toward round-headedness or brachycephaly (relation of breadth of head to length in the living 82 per cent or over) is the Alpine race. This type almost certainly developed on the western slopes of the central Asiatic plateau, probably in the neighborhood of the Hindu Kush and the Pamirs. Its diffusion westward occurred somewhat later than that of the blond, long-headed Nordics.

Within this great White division of mankind I have recognized the following principal races: Australoid, Ainu, Mediterranean, Iranian Plateau, Nordic, and Alpine. These I regard as primary races in the sense that it seems probable that they have differentiated from a common stock, each through inbreeding, the selection of germinal variations, mutations, and environmental adaptations, rather than through intermixture. Secondary races are, on the contrary, composite groups which have arisen through the crossing of two or more primary races, followed by a period of inbreeding in isolation, during which a stabilized physical type emerges from the blending of the racial features of the parent strains. The order in which these primary races of the

White division have been enumerated is quite probably that of their development and diffusion. The Australoid race represents the retention of the most primitive and archaic features and is almost certainly the oldest and first in order of diffusion of this division. It must have been evolved well before the end of the Pleistocene or glacial period, and it seems probable that its continued evolution has been retarded or stopped in the present-day Australians, either through their isolation in an island continent which seems to have had a repressive or inhibiting effect upon mammalian evolution, or for other reasons which we do not understand. It is impossible at present to fix the area of differentiation of this ancient race—it may have been anywhere from the Indian peninsula westward to the Syrian and Palestinian coasts of the Mediterranean. The Ainu race seems to represent the further evolution of this same type in Northeastern Asia and is even closer to the Late Paleolithic types of man found in Europe than are the Australians. The Mediterranean race is surely a further evolution and refinement of this same basic stock, of which the center of characterization appears to have been Mesopotamia, whence it spread in all directions. The Iranian Plateau race may have arisen in that area by mutations of an Ainu-like protorace, particularly effecting nasalization. The depigmentation which characterizes the Nordic stock must have taken place, again, as a result of mutations in the steppe region northeast of the Caspian. Probably the latest racial mutant in this division was toward round-headedness or brachycephaly, a phenomenon which seemingly occurred on the western slopes of the Tibetan Plateau, resulting in the formation of the Alpine race.

Negroid Division

The Pygmy Negritos

The characteristics of the Negrito race as a whole are: extremely small stature and general body size, red-brown to medium brown skin color with black hair and dark brown eyes, very tightly curled or woolly hair. Beyond these, it seems necessary to recognize two strongly demarcated subraces, both of which probably exist in the African and Oceanic areas alike, although their respective distributions have not been accurately ascertained.

Theories as to the origin of these two distinct pygmy Negrito types are necessarily speculative. My present view is that the long-headed, adult type was first differentiated and that the infantile, round-headed type represents a somewhat later mutation, either from the adult type or from some protopygmy stock of presumably mesocephalic or medium-headed form, and perhaps lacking some of the extreme features of the adult type. The infantile type must have undergone the process which is ordinarily called "foetalization"—the retention of characters usually displayed in prenatal or infantile life. The juxtaposition of the two races in the Congo, with the long-headed type farther west, suggests the priority of the latter, which seems ordinarily to occupy a more marginal position than the infantile type. The extinct Tasmanians probably represented one or other of these pygmy Negrito types with slight Australoid admixture.

The Negro Races

There are in Negro Africa several Negroid subraces which probably owe their origin to slight accretions of White blood in the Forest Negro stock. The first of these is the Nilotic Negro, inhabiting the Sudd area and the headwaters of that region.

These Nilotics are enormously tall, elongated of leg, short of body, and narrow of shoulder and chest. They have very black, almost hairless skins, and their shanks are of the exaggeratedly calfless variety. Hair is very woolly, heads usually long, faces broad and short. However, the jaws are not excessively protruding and the nose is not unduly coarse. Finally, the lips are not rolled outward and blubbery to the extent found in the most pronounced Forest Negro type, nor is the chin so retreating and the forehead so low. Although these modifications away from the burly, thickset Negro type may be due to series of mutations, it is more probable that they are caused by admixture with the tall, slender, brunet White stocks of East Africa which are called Hamites.

The Oceanic Negroids are centered in New Guinea and the neighboring islands. The terms Melanesian and Papuan are principally linguistic rather than racial. There are, however, at least two physical types of Oceanic Negroids, neither of which appears to be racially pure. The one has a rather ordinary Negroid nose, low and somewhat broad, with perhaps less thickness of the tip and more circular nostrils than are characteristic of African Negroes. This type, which is often identified with the Melanesian linguistic stocks, seems not to have much of a growth of body hair. The other type has less rounded and more sloping forehead, with bigger brow ridges. The nose is very anomalous indeed, since it is broad and high-rooted, but convex, with a thick and depressed tip. This nose is often called pseudo-Semitic. In this so-called Papuan type the beard is well developed, the lips thin, with the upper integumental lip very long and convex. Body hair is by no means sparse, and tawny or reddish shades occur in some immature individuals. The head hair is not usually very tightly curled, although it must be classified as frizzly or curly.

A recent examination of the physical evidence in this part of the world leads me to believe that the truly Negro racial type in the African sense can hardly be said to exist in the Melanesian-Papuan area. I am inclined to believe that the full-grown Negroid types are largely the result of mixtures of two separate pygmy Negrito races with the Australoid race. Such an hypothesis would account for the heavy brow ridges, depressed nasal root and modified curve of the hair found in most New Guinea Negroids. However, it would not explain the pseudo-Semitic nose, with its remarkably depressed tip. The other and preferable alternative involves the supposition that New Guinea must have been invaded by some convex-nosed stock which has left its dominant feature as a legacy to some of the Negroid-Australoid combinations.

The Foetalized Mongoloids

Nearly all close students of racial history agree that the great Mongoloid division of mankind has been the latest in its diffusion over the habitable world and was probably the last to differentiate. The evidence for this opinion

is based largely upon historical and stratigraphic evidence as to the sequence of racial types all over the world.

Mongoloid physical characters are more strongly expressed in the soft parts of the body than in the skeleton. On the whole, they are concentrated in the skull, as is the case with most racial features. Brachycephalization may be considered provisionally as the retention of a foetal condition. There are, however, some features of the Mongoloid skull which are not babyish. The most notable of these is the strong anterior and lateral jutting of the malars or cheek bones. Another is the commonly elongated face and the flaring hinder angles of the jaws.

Hair form, hair texture, hair pigmentation and distribution are undoubtedly specialized in the Mongoloids. The hair sheaths are so deeply pigmented as to give a blue tinge to the black hair color, but there is not so much melanotic pigment in Mongoloid hair as in that of Negroids.

Certain heavy deposits of subcutaneous fat are characteristic of the Mongoloid—especially over the cheek bones and at the angles of the jaws, also in the eyelids. The fold of skin which often extends across the upper eyelid, obscuring its eyelash implantations and cutting across the inner corner of the eye (so as to cover the caruncula) is generally known as the Mongoloid fold. It is a frequent manifestation in foetuses and infants of European racial stocks and sometimes occurs in Negroes. However, it is far the most common, although variable in the degree of its development, among the Mongoloid stocks. This epicanthic or Mongoloid fold seems to be related, in some fashion, to skin slackness as a result of the flat, infantile nasal root.

The present area of concentration of the pure Mongoloid race is in Northeastern Asia, where a full development of Mongoloid characters is found in such peoples as the Goldi, Giliak, Buriat, and Tungus. The Mongols proper show signs of admixture with a hook-nosed stock. Again, most of the Chinese and the peoples in Southeastern Asia, as well as the Tibetans, are obviously Mongolized on the top of other racial elements. The area of differentiation of the pure Mongoloid type may be somewhat to the west of the present focus, and north of the Tibetan plateau.

THE FORMATION OF SECONDARY OR COMPOSITE RACES IN THE HUMAN SPECIES

Generally speaking, secondary races are of much more recent origin than primary races. Some of them, indeed, seem to have been formed in the last two or three thousand years. This is certainly true in the case of the Polynesians. The process is continuing, but only in the few areas where primary races are in contact.

The Enigmatic Bushman-Hottentot Race

I do not know the answer to this Bushman-Hottentot riddle, but the nearest I can come to a satisfactory solution is something of this sort. The ancestors of the Bushman-Hottentots may have been more or less fully developed pygmy Negrito types which evolved somewhere in Asia in a district

contiguous to, or not far away from, the region which later gave rise to the Mongoloid mutations. These Negritos received some infusion of proto-Mongoloid stock, carrying with it potentialities for the development of Mongoloid features, before the migration to Africa began. In the African environment there occurred in this somewhat mixed stock a further development of some of the ancestral Negrito features, together with a partial expression of Mongoloid tendencies. Whatever is Mongoloid in the Bushman-Hottentot must have been carried with the original migrants in solution when they arrived in Africa. The absence of Bushman-like types in Asia I should attribute to the fact that the Negritos have been completely swamped by recurring Mongoloid invasions, and that the fully developed and culturally more advanced Mongoloids may not have mixed with the Oceanic Negritos in sufficient numbers to produce a Bushman-like hybrid. My postulate is that the Bushman is physically and by blood much more Negrito than Mongoloid, and that a similar type in the Oceanic area would be expected only if a predominantly Negrito population should receive a minor infusion of Mongoloid blood. This may or may not be the correct explanation of the phenomena under discussion.

Tri-Hybrid Races

The East Indian Race

The East Indian or Dravidian race seems to have been composed by adding a major Veddoid or Australoid component to a minor substratum of Negrito, then swamping the blend with brunet Mediterranean White. It seems probable that this White element was responsible for the introduction of the Aryan languages which may have come into India about 1500 B.C. In the northwest of the country there have also been admixtures of the hook-nosed, dolichocephalic, Iranian Plateau race, which is more notably hairy than the other Indian stocks. This admixture seems to have resulted in tall stature. Finally, in Kashmir there is evidence of some infusion of a blond stock, doubtless Nordic. Here and there Mongoloids have trickled into India through the Tibetan passes, but, on the whole, the Mongoloid admixtures seem to have been so slight as to leave very little impression upon the composite racial type. It is interesting to note that the higher Indian castes usually display fewer of the primitive racial elements than do the low castes, in whatever part of the country. But as one goes south the earlier strata in the populations appear more strongly represented in the blends, so that the Southern Indian Brahmin, although carrying more Mediterranean race features than his caste inferiors, is yet more aboriginal in appearance than the lower caste person farther to the north.

The Polynesian Race

It seems improbable that the earliest peopling of Polynesia could have taken place much before 500 B.C., and the occupations by primitive peoples were apparently completed about the middle of the fourteenth century A.D. Although the physical types of Polynesians vary individually and to some

extent in the different island groups, there has been evolved a smooth and recognizable racial blend which, with local modifications, prevails all over the vast area.

The Polynesians are a very comely race, with beautifully made bodies and handsome faces. They exhibit none of the featural disharmony which many theorists have associated with race crossing. Clearly enough they are of tri-hybrid origin—a Negroid or Negritoid element, plus a very strong infusion of brunet White stock, with a slight Mongoloid dash to top off the whole. Arguments about their racial origin center upon the question as to whether the different elements were blended as the consequence of separate migrations into the Pacific area of Negroids, White, and Mongoloids, in that order, or whether, on the contrary, all of the racial strains were carried in solution by each of the successive waves of migrants. There is also a good deal of disputation as to the routes of migration.

Composite Races with Mongoloid Overlay

The Indonesian-Malay Race

Indo-China, Japan, and the Malay Archipelago are peopled, in large part, by a composite or secondary race which has been formed by the Mongolization of one or more submerged earlier racial elements. Throughout the most of this area there are evidences of the presence of dark-skinned, curly, or frizzly haired peoples with long heads. Occasionally there survive, as in the Malay Peninsula and the Andaman Islands, isolated enclaves of Negritos who are brachycephalic. Probably there are also submerged Australoid strains present in minor proportions. However, all of these primitive strata have been overlaid first with a thick stratum of long-headed, brunet White stock, and then thoroughly swamped with Mongoloid populations stemming from the mainland of Asia.

The American Indian

I am inclined to believe that the earliest migrants to the New World were small, long-headed persons with heavy brow ridges, prognathous faces, broad noses, dark skins, and wavy or curly hair. They would represent such a racial combination as occurs when a primitive brunet Mediterranean White has taken on some Australoid and Negroid or Negritoid features—much like the Todas of Nilgiri Hills in Southern India. Perhaps the next waves brought big-nosed dolichocephals of the Iranian Plateau race, but already slightly Mongolized, straighter in head hair, and with more sparse body hair and incipient Mongolization of the cheek bones. There followed the later and more dominant round heads, with possibly a full development of Mongoloid specializations. In the ensuing mixtures of strains in the New World, Mongoloid skin color, Mongoloid hair form, and Mongoloid cheek bones were ordinarily dominant, but the beaky nose of the Western Asiatic highlands nearly always survives at the expense of the low-bridged Mongolian blob.

Composite White Races

The Armenoid Race

Studies of Armenians and Syrians by some of the younger Harvard anthropologists—Carl Seltzer, Walter Cline, and Byron Hughes—have recently proved that the so-called Armenoid race is really a rather unstable blend of several different racial elements which have interbred in the Near East. It is doubtful whether it deserves classification as a secondary or composite race; it is more in the nature of a subrace. As yet unpublished, researches of Dr. Byron Hughes on some 1500 adult male Armenians residing in the United States and upon a considerable number of first generation Americans of Armenian parentage, have cleared up the Armenian racial problem quite conclusively. The type varies markedly in different regions of Armenia, apparently according to the varying proportions of the racial constituents which are in the blend. These are ordinary brunet, long-headed Mediterraneans with dark skins and curly hair, round-headed brunet Alpines with square faces and blobby noses, and thickset build; the brunet, dolichocephalic Iranian Plateau race, recently isolated by Dr. Henry Field, with a final dash of blond, long-headed, horse-faced, fair-skinned and blue-eyed Nordics. The least important and least constant element in the blend is this Nordic strain. When present, it has the effect of elevating stature, modifying the dark eyes to mixed and often greenish tints, and possibly of elongating the face.

The Dinaric Race

The dominant strains in this mixed type are Iranian Plateau, Alpine, and Nordic, but the Nordic seems much more heavily represented than it is in the Armenoid subrace.

East Baltic Race

In Finland, Poland, and the Baltic states there occurs a well-differentiated and stabilized physical type which is usually called the "East Baltic Race." The most outstanding feature of this type is its feeble pigmentation of skin, hair, and eyes. The hair is tow-color or almost white, more rarely a pale yellow, the eyes gray or light blue, the skin tawny white or rosy white, but more often the former. The head hair is straight and the body hair generally somewhat sparse. Stature is medium to tall, and the body build is ordinarily thickset. The head is very brachycephalic and somewhat flat at the back, whence the nickname, "square heads."

My own suggestion is that East Baltic blondness is due to physiological disturbance set up primarily by mixture between Alpines and Lapps, and selected for multiplication and survival by the Baltic climate. Of course, such blondness has been reinforced by some infusion of Nordic blood, but the origin of Nordic blondness is, in itself, somewhat of a mystery.

The Keltic Subrace

In Scotland, Ireland, and to a lesser extent in England, Wales, and Cornwall, there occurs a very tall, long-headed type of man with a long, compressed

face, high, narrow nose, deep jaws, and a curiously disharmonic pigment combination. The hair is usually very dark brown, often almost black, and wavy or even curly. Beard and body hair are moderately developed. The skin color is light and sometimes very florid; the eyes are usually deep blue. Very frequently in this type the hair is red and the eyes are greenish. It is easy enough to get at the derivation of these Keltic types, because the parent strains are abundantly present in the same area. They are, on the one hand, the conventional Nordic type—dolichocephalic, blond as to hair, and blue or gray as to eye color; on the other, an even taller, longer-headed, brunet stock with curly or wavy hair, which is often called the Atlanto-Mediterranean race.

The Psychological and Cultural Implications of Race

It is a reasonable presumption that psychological variations accompany the morphological differences which distinguish the hereditarily constituted groups which we call races. As a matter of fact, most of the characteristics which we use for racial discrimination in living groups—such as pigmentation, hair form, et cetera—are merely morphological expressions of physiological differences. The mechanism which controls growth and racial differentiation, as well as sex differentiation, is the endocrine system, commonly known as the ductless glands. These include the pituitary, the thyroid, the parathyroids, thymus, adrenals, and the gonads. The functioning of this little understood endocrine system is partially determined by individual and familial heredity, partially by racial heredity, and ultimately no doubt by environmental selection. So little work has been done upon the subject of racial variations in physiology that our knowledge of it is practically negligible.

We are only certain of the fact that the range of individual psychology within any race is so great that interracial ranges must be overlapping to a very considerable extent. Mean differences between racial groups are certainly far less than differences between individuals of the same race.

THE RESULTS OF RADICAL RACE MIXTURES BETWEEN PRIMARY RACES

The entire subject of race has been so obscured by low-lying clouds of ignorance, prejudice, and superstition that few serious students have attempted to penetrate its miasmic confines. In this generally insalubrious area for the timid and the cautious investigator the gases are thickest and most poisonous in the depressed spots which are the sites of hybridization.

Taking it all in all, it seems undeniable that a stock can be improved by inbreeding and selection which eliminates the inferior recessives. This process, however, may be accompanied by some diminution in size and fertility on the part of the dominants. Outbreeding, on the contrary, is likely to carry with it increase in size and vigor and certainly a wider range of physical and mental potentialities. It should be noted that hybrid vigor seems to include increased fertility, and often improved vitality and longevity. But outbreeding also produces its crops of persons in whom the inferior, recessive genes are doubled and come to outward expression. The variety of inferiors, as of average

individuals and of superiors, is also increased. There is no way to beat the genetic game simply by breeding. You can breed for better types and get them, but there are also thrown off in the process runts and inferiors which must not be allowed to perpetuate their infirmities and deficiencies.

Negro-White Mixtures and White-Mongoloid Crosses

The general results of studies of primary racial crosses between Negroes and Whites, and between Mongoloids and Whites, offer interesting evidence as to the types of featural mosaics which are stabilized in the hybrids and afford also many indications of the dominance of this or that morphological variant. On the whole, they support the contention that inheritance is Mendelian with segregation and dominance. However, it is clear enough that dominance is often incomplete and that most bodily features are not controlled by the interaction of a single pair of genetic factors. It is for this reason that it is commonly stated that racial mixtures result in blends. They are not really blends, but mosaics.

Hybrid vigor in size and strength has not as yet been demonstrated for hybrids of the types we have been discussing. It is suggested in the stature of Negroids in Africa, but I do not think that this indication is supported substantially by the American data. In my own series of Negro and Negroid criminals, both of large size, the Negroids or mixed bloods are taller than the putatively pure Negroes, but shorter than the Old American Whites. But the mixed bloods are the heaviest and the Whites the lightest. There is then the possibility of hybrid vigor in weight, but it is only a possibility.

RACE MIXTURES BETWEEN PRIMARY AND SECONDARY RACES AND BETWEEN ALLIED RACES

Secondary or composite races are stabilized blends derived from the intermixture of primary races. Presumably, most of the members of such races are heterozygous dominants in the majority of their features and homozygous or double dominants in regard to others. Since the heterozygous individuals are genetically less stable than those which are homozygous, we should expect crossings between two secondary races to bring about the breakdown of type combinations found in each and the formation of new ones. We should expect also new arrays of dominants and recessives derived from the segregation of factors in the two stocks combined.

If a secondary race crosses with another secondary race, or with a primary race which has previously contributed to both blended secondary races, we may expect the reinforcement of characters derived from that primary race to skew the hybrids over toward the original characters of the latter. For example, if Polynesians are a tri-hybrid race derived from White, Negroid, and Mongoloid elements, we may expect crossings of Whites with Polynesians to result in more European-looking hybrids than would ordinarily be expected in race mixture, because the White strain is present, although often recessive, in the Polynesian stock.

The breaking up and recombination of characters resulting from secondary

racial admixture often provides a clue as to the origins of the composite races, since the elements fused in the secondary races are resolved in the mixture. Again individual cases of unusual crossings between races which are not at present in contact, except perhaps in certain cosmopolitan regions, often demonstrate the origins of secondary races which have sprung up elsewhere in the world.

Hottentot-White Mixture in South Africa

The pioneer study of Professor Eugen Fischer, of Berlin University, indicated that hybrid vigor does occur in this cross of widely separated races, that fertility and vitality are by no means impaired, and that Mendelian inheritance seems to be operative in race mixture. No subsequent study of equal scope has been undertaken in South Africa. Observations of recent writers tend to confirm Fischer's results.

East Indian-White Mixtures

It is clear enough that the Anglo-Indians constitute a most important class of public servants in India and that they are the chief instruments for the preservation of British rule. Their position amply indicates their intelligence and their ability to acquire European educations. Their rapid increase is sufficient evidence of their fertility. Data pertaining to their biological status are admittedly inadequate. The sedentary nature of their occupations probably is associated with slightness of physique, but we have no means of knowing to what extent their inferior physical endowment, if it is inferior, is the result of sedentary education as contrasted with inheritance. Cedric Dover in "Half-Caste" speaks of the athletic prowess of many Eurasians who have had the advantages of the upper class environment. Edgar Thurston also found that Eurasian boys who were brought up in an English school were physically well developed.

Kisarese-Dutch Crosses

In most characteristics the Kisarese hybrids apparently are intermediate between the natives and the Dutch. There is no evidence of heterosis or hybrid vigor. Rodenwaldt made a conscientious effort to trace the inheritance of physical features by the application of Mendelian rules, but his data are so scanty that the results are inconclusive. However, he was able to establish the probability of segregation and dominance in some few metric and morphological features. Hybrid noses with a dominance of high bridges, dominance of great head breadth, intermediate and progressive pigmentation of hair, skin and eyes, with juvenile blondness, are a few of the phenomena encountered.

Australian-White Mixtures

In Australia the striking physical and cultural characteristics of the aborigines are so strongly contrasted with those of the British White population that a study of hybridization between the races involved should yield results of the greatest scientific interest. Unfortunately, little or no effort has been made to investigate this subject up to the last year.

In May, 1938, a joint expedition of Harvard University and the University of Adelaide took the field for the purpose of securing ample and definitive data on this subject. In this enterprise the genealogy, linguistics, sociology, and material culture are being studied by Norman Tindale and the physical anthropology by Joseph B. Birdsell. All areas of Australia and Tasmania are being investigated, and at latest reports more than 1800 individuals had been completely studied, all of whose genealogies had been recorded. Western Australia remains to be visited. This material includes series of both parent stocks, half-breeds, quarter-breeds, and various other back crosses. In two years it may be expected that fuller information on race mixture in this area will be available than in almost any other part of the world. The preliminary indications of dominance of more highly evolved racial types over the Australoid are of very great interest and quite in accordance with expectation.

Polynesian-White Crosses

The Pitcairn and Norfolk Islanders

By and large, the descendants of the mutineers and the Tahitian women present an example of the effects of close and long-continued interbreeding which is biologically even more interesting than the nature of inheritance of features from two distinct racial stocks. The principal manifestations in the combined phenomena are hybrid vigor through several generations, initial increase of fertility and subsequent diminution, maintenance of health and longevity in spite of inbreeding, dominance of White racial characters. The last is due not alone to Mendelian segregation and dominance, but also to the fact that the Polynesian race carried a White element in its composition which makes the hybrids more than half White when this latent White fraction is added to the half of English blood.

Polynesian Mixtures in Hawaii

On the whole, it appears that the general status of the part-Hawaiian is intermediate between that of the parent stocks, both biologically and sociologically. Evidences of hybrid vigor, whether physical, mental, or social, are neither numerous nor impressive. On the other hand, there is no suggestion that biological or sociological deterioration arises from any of these mixtures. It is even possible that the part-Hawaiians are the most fertile stocks of the islands. At any rate, they seem to show the most rapid increase.

Indian-White Mixtures

In the New World mixtures of European Whites and Negroes with American Indians have been much more extensive than is commonly believed. There can be little doubt that the populations of South America and Central America, including Mexico, are basically Indian with varying degrees of South European White admixture. In some of the countries large Negro elements have been added. Indian strains in the Old American population of the United States are probably stronger than one is ordinarily led to believe, especially in the south and the west.

The most complete and satisfactory study of race mixture between Whites

and Indians is that made by Dr. George D. Williams upon Maya-Spanish crosses in Yucatan. Race mixture in this area is of such long standing that it is impossible to secure information as to the genetic composition of individuals studied or pedigrees indicating the proportions of blood from the respective parent races. In Yucatan race mixture has continued for a period of more than 350 years. Williams secured a series of 880 men and 694 women of varying degrees of mixture of Maya and Spanish strains. He then divided his series into five subgroups on the basis of their possession of certain non-adaptive and non-mensurable characters which are of value as racial criteria of the American Indian stock.

The Intermixture of White Races and the Formation of National Breeds

Virtually no studies of the results of race mixtures between allied races have been made, because these are not generally regarded as race mixtures. The physical differentiae of allied races are not sufficiently marked to make the offspring of their crossings physically distinctive and sociologically set apart as anomalous groups. Such mixtures have gone on from prehistoric times so that it is now almost impossible to isolate pure racial stocks. They survive, if anywhere, only in out-of-the-way places. Most individuals of an apparently pure racial type are probably the result of the re-segregation of combinations of racial characters which once went into the melting pot.

If we look at the course of prehistory and of history from the point of view of the physical anthropologist, we must recognize that most of the sudden efflorescences of civilization can be synchronized with new racial infusions, followed by inbreeding and a hybrid vigor which is certainly cultural, and quite probably biological.

THE WAGNER FREE INSTITUTE OF SCIENCE

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of the
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PUBLISHED BY THE INSTITUTE
SYDNEY L. WRIGHT, *Editor*

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WAGNER FREE INSTITUTE OF SCIENCE

FACULTY

SAMUEL C. SCHMUCKER, *Dean* IVOR GRIFFITH, *Secretary*

HONORARY

William B. Scott, A.M., Ph.D., LL.D., *Geology*

ADMINISTRATIVE

Department of Engineering
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Department of Biology
Samuel C. Schmucker, Ph.D., Sc.D., *Zoology*
George B. Kaiser, *Botany*

Department of Physical Science
Leslie B. Seely, B.A., Ph.D., *Physics*
David W. Horn, Ph.D., *Inorganic and Physical Chemistry*
Ivor Griffith, Ph.M., Sc.D., *Organic Chemistry*

Department of Geology and Paleontology
Benjamin F. Howell, A.M., Ph.D.

Carl Boyer, *Director*
John G. Hope, *Curator*

HISTORY

The Wagner Free Institute of Science was founded in 1847 by William Wagner, a citizen of Philadelphia.

In his early life William Wagner became associated with Stephen Girard in the extension of Girard's mercantile business. While in Girard's employ he had the opportunity to visit foreign countries, and being interested in scientific pursuits, he made a study of scientific institutions abroad and collected natural history specimens which afterward formed the nucleus for the collections in the museum of the Institute.

The Institute, itself, had its inception in a series of free lectures delivered by Professor Wagner in his home. These lectures, begun in 1847, were continued until 1855 when the Institute was incorporated by act of legislature.

A large measure of credit is due Mrs. Louisa Binney Wagner, Professor Wagner's wife, for sympathy, understanding and active coöperation in the early days of the founding of the Institute.

In 1855 a faculty was appointed and the work was continued in a new location at 13th and Spring Garden Streets, the City of Philadelphia giving permission for the use of Commissioners' Hall. Some years later Professor Wagner decided to erect a building on the present site at Seventeenth Street and Montgomery Avenue. This building was completed in 1865 and occupied immediately.

William Wagner died in 1885 and the management of the Institute was transferred to a Board of Trustees.

In 1901 a wing was added to the building for the use of a branch of the Free Library of Philadelphia.

INSTRUCTION

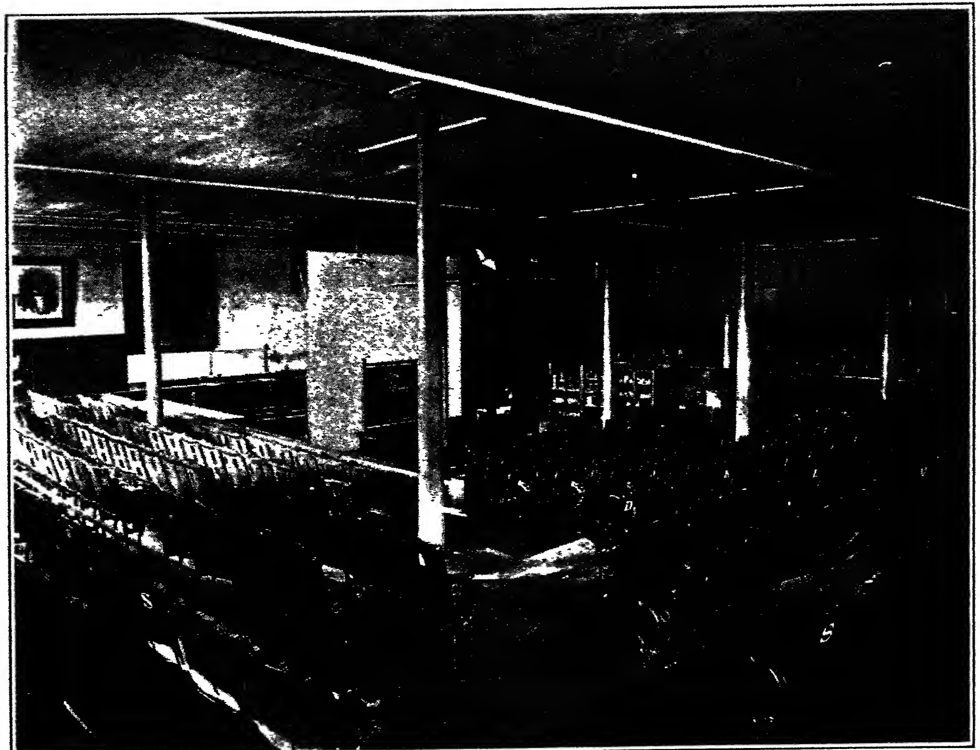
Lectures and Class-Work

Instruction at the Wagner Free Institute of Science is conducted by means of lectures supplemented by class work. There are no tuition fees.

Persons may attend lectures without registering for the classes if they so desire. Those registering for the classes are required to hand in a weekly paper and are admitted to an examination at the end of the term. Those persons successfully passing the examination are awarded certificates for the year's work.

There are seven courses of scientific lectures covering a period of fourteen weeks each for four years. On the successful completion of four years' work a Full Term Certificate is awarded.

The closing of each lecture season is marked by Commencement Exercises.



AUDITORIUM

Museum

Museum

The Institute maintains a natural history museum containing more than 21,000 specimens illustrating the various branches of natural science.

The collections are arranged especially for study. The museum is open to visitors on Wednesday and Saturday afternoons from 1 P.M. until 4 P.M., except legal holidays.

On each Monday evening at 7 P.M., from September to May, a "Museum Talk" is delivered in the museum, the speaker using the specimens in the museum to illustrate the lecture.

Teachers and students desiring to use the museum for special studies will be admitted upon application at the office.

Libraries

The Reference Library of the Institute contains over 25,000 bound volumes and approximately 150,000 pamphlets on scientific subjects, classified and arranged for ready reference. There are also many foreign and domestic periodicals on file. The library is open to the public as well as to students from 10 A.M. to 9 P.M., Monday through Friday. Saturday 9 A.M. to 5 P.M.

The Free Library of Philadelphia maintains a branch library in the building, known as the Wagner Institute Branch, from which books may be taken out under the rules of the Free Library.

Publications

The publications of the Institute consist of three series:

Transactions: begun in 1885 and discontinued in 1927.

Publications: succeeding the Transactions. These Publications are issued at irregular intervals.

Bulletin: issued quarterly.

SPECIAL LECTURES

Westbrook Free Lectureship

The Westbrook Free Lectureship is supported by the income from an endowment provided by Dr. Richard Brodhead Westbrook and his wife, Dr. Henrietta Payne Westbrook. The lectureship was established in 1912 and provides for one course of lectures each year. These lectures cover a wide range of topics and a list of those so far given may be found on page 47.

Fannie Frank Leffmann Memorial Lectureship

The income of a fund given by Dr. Henry Leffmann is applied to occasional special lectures under the Memorial Lectureship. These lectures are popular in character.

The *Philadelphia Natural History Society* is affiliated with the Institute and holds meetings on the third Thursday of each month from October to May.

RESEARCH

The Institute has carried on research work since 1885 in various departments of science. Results of research have been published from time to time in the Transactions, Publications and Bulletin.

The Institute is also the recipient of the income from two funds established by Dr. Henry Leffmann. This income is devoted to research in chemistry.

CERTIFICATES AWARDED AT CLOSING EXERCISES, MAY 17, 1939

FULL TERM CERTIFICATES

BOTANY

Adon E. Burnham
Francis H. Doyle
Nathan Fitelson
John J. Kane
Harriette A. Lyon
Lilla P. Murdoch
Lola I. Poppleton
Edith G. Ramsey

INORGANIC CHEMISTRY

Joseph Sussna

ENGINEERING

Bernard Dunn
Ralph A. Hafner
J. Francis Sibre

ZOOLOGY

Carroll R. McDonnell
Blanche Manning
Thomas L. Strong

GEOLOGY

Arthur B. Guest
Emanuel Hocking
Blanche Manning

1938-1939 CERTIFICATES AWARDED

BOTANY 4

Anthony Albrecht
Dorothy M. Burnett
Adon E. Burnham
Francis H. Doyle
Nathan Fitelson
William J. Gane
Oscar F. E. Gentieu
Mildred I. Graver
John F. Hardecker
E. Frances Hervey
Daniel Hofheimer
John G. Hope
John J. Kane
Harriette A. Lyon
Carroll R. McDonnell
William L. Mahn
Lilla P. Murdoch
Lola I. Poppleton
Edith G. Ramsey
Caroline Reed
Mary Reed
Mary H. B. Schrack
Samuel Shober
George F. Stauffer
Lelia M. Stauffer
William Thompson
Merlin Wand
Agnes R. Zimmer

INORGANIC CHEMISTRY 2

Charles H. Angstadt
Ina Bein
Edwin R. Cornish
William J. Gane
Nicholas Gungura
Myron Kreskovsky
Bob D. Lehman
Rose Millstein
Sophie Millstein
Gene E. Morris
John W. Nocito
William B. Reiff
Frank Rush
Samuel Shober
Harry Silver
Joseph Sussna
William Thompson
Earl A. Wagner
Raymond S. Whitehead

ORGANIC CHEMISTRY 2

Ina Bein
William J. Gane
John Grava
Margaret L. Hubbard
Samuel Michaelson
John W. Nocito
Ralph M. Olson
William B. Reiff
Clifford S. Shipley
Samuel Shober
Harry Silver
Thomas L. Strong
Raymond S. Whitehead
William Wood

ENGINEERING 4

John M. Bley
Lorenzo V. Blackston
Joseph P. Burke
William H. Conley
Charles B. Davidson
Joseph Davidson
Bernard Dunn
Joseph S. Ferringo
Beecher Finch
Paul A. Fisher
Ralph A. Hafner
Edward Herrera
Frank M. Holz
Peter Johns
Louis S. Langford
John K. Leister
William M. Lubarsky
John F. McDevitt
Wilfred R. Newton
L. Gilbert Obermiller
Albert R. Sabaroff
George H. Shandle
J. Francis Sibre
Harry D. Smith
Charles I. Wilkinson
Daniel V. Wilkinson
Norman T. Wineke

ZOOLOGY 3

Aaron Anton
Elizabeth Anton
Kitson A. Broadbelt
Helen G. Durner
Nathan Fitelson
Anne B. Gehring
Eileen E. Hand
John F. Hardecker
Harriette A. Lyon
Carroll R. McDonnell
Blanche Manning
Ralph M. Olson
Gertrude M. Redheffer
Ann Sayen
Samuel Shober
Thomas L. Strong
Albert Succi
William M. Thompson
Gertrude Vieweger

GEOLOGY 4

Ina Bein
William H. Conley
Arthur B. Guest
Emanuel Hocking
Blanche Manning
Albert H. Petri
Albert Schwabeland
Samuel Shober
Albert Succi

PHYSICS 1

Charles H. Angstadt
Adolph W. Awot
Ina Bein
William H. Conley
Edwin R. Cornish
Yaroslav J. Fostyk
Nicholas Gungura
William D. Haenger
Edwin E. Hahn, Jr.
Myron Kreskovsky
Benjamin J. Patton
Samuel Shober
Albert Succi

FACULTY

SAMUEL CHRISTIAN SCHMUCKER

A.M., M.S., Sc.D., Muhlenberg College.
Ph.D., University of Pennsylvania.
Professor of Biological Sciences, State Teachers College, West Chester, Pa., 1895–1923.
Science Department, Summer Schools, Chautauqua, N. Y., 1906–1928.
Lecturer on Biology, Brooklyn Institute of Arts and Sciences, 1905–1933.
Professor of Botany, Wagner Free Institute of Science, 1908–1926.
Professor of Zoology, Wagner Free Institute of Science, 1926 to date.
Dean of the Faculty.
Author of

"The Study of Nature." (Lippincott Co., Philadelphia.)
"The Meaning of Evolution." (Macmillan Co., N. Y.)
"Man's Life on Earth." (Macmillan Co., N. Y.)
"Heredity and Parenthood." (Macmillan Co., N. Y.)

JOHN WAGNER, Jr.

B.S. in C.E. 1913, University of Pennsylvania.
C.E. 1920, University of Pennsylvania.
1913–1916, Draftsman, Phoenix Bridge Company.
1916–1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921–1926, Assistant Supervisor Track, Reading Company.
1926–1928, Supervisor Track, Reading Company.
1928–1936, Industrial Agent, Reading Company.
1936 to date, Assistant General Freight Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date.

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899–1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906–1915.
Head of Science Department, Germantown High School, 1915–1923.
Principal, Roxborough High School, 1923–1924.
Principal, Germantown High School, 1924 to date.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906–1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:

"Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
"Ether Waves and the Messages They Bring," Transactions of the Wagner Free Institute of Science.
"The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900–1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901–1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916–1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921–1937.
Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.
Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Sc.D. (Hon.), Bucknell, 1934.
Director of Research, John B. Stetson Company, 1925 to date.
Research Adviser, McNeil Laboratories, Philadelphia, 1937 to date.
Director of Laboratories, Stetson Hospital, 1920 to date.
Editor, American Journal of Pharmacy, 1921 to date.
Professor of Pharmacy, Philadelphia College of Pharmacy and Science.
Dean of Pharmacy, Philadelphia College of Pharmacy and Science, 1938 to date.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Member American Chemical Society.
Member American Pharmaceutical Association.
Publications:
- "Recent Remedies," 1926 (revised 1928). International Publications, N. Y.
- "Popular Science Lectures" (Editor) (thirteen volumes). Phila. College Pharmacy and Science, Phila.
- U. S. Dispensatory (Collab. Editor). Lippincott, Phila.
- Formula Book, A. Ph. A. (Editor). Lippincott, Phila.
- A Science Miscellany, International Printing Company, Phila.
- Contributor to current chemical, pharmaceutical and medical literature.

GEORGE BRINGHURST KAISER

Educated in private schools.
Graduate, Franklin School.
After graduation spent several years in intensive botanical study and field work in northeastern United States.
Secretary of the Botanical Society of Pennsylvania for seven years and leader of its field trips.
Professor of Botany, Wagner Free Institute of Science, 1927 to date.
Curator, Moss Herbarium, Sullivant Moss Society.
Treasurer, Delaware Valley Naturalists' Union.
Member, Academy of Natural Sciences.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology and Stratigraphy in Princeton University.
Lecturer on Paleontology and Geology, University of Pennsylvania.
Acting Curator, Department of Paleontology, Academy of Natural Sciences of Philadelphia.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Member of the Palaeontologische Gesellschaft.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Secretary of the International Paleontological Union.
Editor of the section of General Paleozoology of *Biological Abstracts.*
American Editor of *Palaeontologisches Zentralblatt.*
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, Colorado School of Mines, as a consulting paleontologist and research associate.

REGULAR LECTURES, SESSION OF 1939–1940

BOTANY 1

PROFESSOR KAISER

Morphology

Lectures begin at 8 P. M.

1. Monday, September 11.
   Seed and Embryo. Parts and uses. Growth of seedling.

2. Monday, September 18.
   Root. Composition, duration and kinds. Special functions.

3. Monday, September 25.
   Stem and Bud. Subterranean and aerial stems. Kinds of buds.

4. Monday, October 2.
   Leaf. Parts, uses. Kinds and forms. Special functions.

5. Monday, October 9.
   Flower. Parts and their uses. Perfect and unisexual flowers.

6. Monday, October 16.
   Phyllotaxy and Anthotaxy. How leaves and flowers are placed on the stem and in the bud.

7. Monday, October 23.
   Fruit. Kinds, parts, source and development.

8. Monday, October 30.
   Pollination and Fertilization. Deposition of pollen on stigma and the fertilization which follows.

9. Monday, November 6.
   Cell. Form and composition. Contents and derivatives.

10. Monday, November 13.
    Mitosis. The process of indirect nuclear division and the Reduction form.

11. Monday, November 20.
    Differentiations of the Cell. Building the cell wall. Its constituents. Many kinds of cells.

12. Monday, November 27.
    Contents of the Cell. The manifold inclusions of the cytoplasm.

13. Monday, December 4.
    Tissues. Actively dividing and permanent. Epidermal, mechanical, conducting and secretory.

14. Monday, December 11.
    Aerial Stem. Distribution of xylem and phloem, medulla and medullary rays. Cambium, phellogen. Sap and heart wood.

Field Trip

The class in Botany will be conducted on a field trip under the leadership of Professor Kaiser. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

INORGANIC CHEMISTRY 3

PROFESSOR HORN

Descriptive Chemistry

Lectures begin at 7.45 P. M.*

1. Tuesday, September 12.

   Carbon. Sources, properties. Lampblack, graphite. Diamonds, real and artificial. Coal, petroleum, asphaltum, natural gas. Hydrocarbons, acetylene. Carbon tetrachloride. Carbides.

2. Tuesday, September 19.

   Carbon (Continued). Carbon monoxide; water gas, producer gas. Carbon dioxide, carbonates, bicarbonates. Carbon disulphide.

3. Tuesday, September 26.

   Inorganic Compounds of Carbon and Nitrogen. Cyanides, ferrocyanides, ferricyanides, nitroprussides. Cyanates, sulphocyanates. Cyanamide. Chemistry of blue-printing.

4. Tuesday, October 3.

   Silicon. Occurrence, preparation, properties. Silicic acids. Colloidal silicic acid. Silicates; glass, pottery, water glass. Silicon tetrafluoride. Fused quartz.

5. Tuesday, October 10.

   Significance of the term "Metal." Historical. Electromotive series. Noble and base metals. Metallic properties. Metallurgy. Metallography. Alloys. Amalgams.

6. Tuesday, October 17.

   Sodium. Salt, nitre, and borax. Leblanc and Solvay Processes. Sodium bicarbonate, carbonate, hydroxide, metal, oxide and peroxide. Baking powders, chemical fire-extinguishers.

7. Tuesday, October 24.

   Potassium, Rubidium, Caesium. Potash. Causticizing potash. The Stassfurt deposits, other sources of potassium salts. Saltpetre. Fixed alkalis. Hydrolysis. Spectrum analysis.

8. Tuesday, October 31.

   Lithium, Barium, Strontium. The metal lithium. Lithia waters. Barytes, precipitated barium sulphate. Lithopone. Barium oxides. Strontium salts. Fire-works.

9. Tuesday, November 7.

   Calcium. Limestone, other natural carbonates of calcium. Hardness in water. Limestone caverns. Gypsum, plaster of Paris. Mortar, cement. Bones, phosphate rock, fertilizers.

10. Tuesday, November 14.

    Magnesium and Zinc. Sources, preparation, properties. Magnesite, dolomites. Magnesium salts. Metallic magnesium and zinc. Industrial uses of the metals. Zinc white.

11. Tuesday, November 21.

    Aluminum. Occurrence, preparation, properties. The alums. Uses of metallic aluminum. Clay. Emery. Gems. The Goldschmidt Process, thermite. Lakes.

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* Please note the hour.

12. Tuesday, November 28.
    Manganese and Chromium. Occurrence, preparation. Multi-valence. Manganese salts, permanganates. Manganese alloys. Chromium salts, chromates, and poly-chromates. Nichrome. Rustless steels.

13. Tuesday, December 5.
    The Analytical Scheme of the Metals. The subdivision of the metallic ions into groups. Group separations. Sub-group separations. Confirmatory tests. Handling "Unknowns."

14. Tuesday, December 12.
    Metal-Ammonia Compounds. Some complex ammonia compounds of mercury, copper, cobalt, nickel, platinum and chromium. Werner's Hypothesis. Stereo-isomerism in inorganic compounds.

ORGANIC CHEMISTRY 3

PROFESSOR GRIFFITH

Cyclic Hydrocarbons

Lectures begin at 8 P. M.

1. Wednesday, September 13.
   Destructive Distillation. Fractional Distillation. Coal tar (the ugly duckling of organic chemistry), wood tar; their industrial production and general uses.

2. Wednesday, September 20.
   The Genealogic Table of Old King "Coal." Fractionating coal tar. Commercial products—light oil, dead oil, heavy oil, anthracene oil.

3. Wednesday, September 27.
   Benzene and its Homologues. Kekulé and his one ring circus. Theories of molecular structure of cyclic hydrocarbons.

4. Wednesday, October 4.
   Derivatives of Benzene. Aromatic aldehydes. Alcohols, esters.

5. Wednesday, October 11.
   Derivatives of Benzene (Continued). Aromatic acids, benzoic, salicylic, etc.

6. Wednesday, October 18.
   Derivatives of Benzene (Concluded). Phenols: Phenol, cresol, resorcinol, pyrogallol.

7. Wednesday, October 25.
   Synthetic Medicines from Coal Tar. The fever chasers: Acetanilid, phenacetin, antipyrin.

8. Wednesday, November 1.
   Synthetic Medicines from Coal Tar (Concluded). The sleep coaxers and germ killers: Barbital and its compounds. Hexyl-resorcinol. Arsphenamine. Chloramine.

9. Wednesday, November 8.
   The Nitrogen Branch of the Coal Tar Family. Anilin—its homologues and derivatives, pyridin and quinolin. Nitrobenzene.

10. Wednesday, November 15.
    The Rainbow in a Barrel. Dyes from coal tar. Perkins and his epoch-making mistake. Classification and general uses.

11. Wednesday, November 22.

    Dyes from Coal Tar (Continued). Color and chemical constitution. Coal tar dyes in the textile industries. The new American dyestuffs industry.

12. Wednesday, November 29.

    Dyes from Coal Tar (Continued). Theories of dyeing. The practice of dyeing.

13. Wednesday, December 6.

    Dyes from Coal Tar (Continued). Dyes as indicators and laboratory stains. Dyes in disease. Dyes in the paint and lacquer industry.

14. Wednesday, December 13.

    Dyes from Coal Tar (Concluded). Uses in food-stuffs. Certified dyes. Detection and distinction from natural colors.

ENGINEERING 1

PROFESSOR WAGNER

Materials of Engineering Construction

Lectures begin at 7.45 P. M.*

1. Friday, September 15.

    Properties of Engineering Materials. Force. Stresses. Properties. Testing machines.

2. Friday, September 22.

    Stone. Classification. Composition. Physical properties. Unit stresses.

3. Friday, September 29.

    Brick. Composition. Manufacture. Physical properties. Special uses.

4. Friday, October 6.

    Lime and Cements. Composition and manufacture of lime and its uses. Classification. Manufacture. Physical properties. Tests and uses of cements.

5. Friday, October 13.

    Mortar and Concrete. Sand. Lime mortar. Cement mortar. Grout. Strength. Uses.

6. Friday, October 20.

    Concrete and Mastics. Concrete: proportions, mixing, consistency, placing, and surface finish. Reinforced concrete: strength, uses. Mastics: composition, occurrences in nature, uses.

7. Friday, October 27.

    Wood. The tree. Composition. Cell structure. Classification. Preparation for the market.

8. Friday, November 3.

    Wood (Continued). Seasoning, shrinkage. Durability. Enemies of wood. Preservation processes. Physical properties and unit stresses.

9. Friday, November 10.

    Cast Iron. Ores of iron. Occurrence in nature. Construction of the blast furnace. Metallurgy of the blast furnace. Physical properties and uses.

10. Friday, November 17.

    Wrought Iron. Chemical and physical composition. The puddle furnace. Physical properties. Unit stresses.

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* Please note the hour.

11. Friday, November 24.

    Steel. Definition. Alloys with carbon, nickel and chromium. Processes of manufacture. Recarbonization of wrought iron.

12. Friday, December 1.

    Steel (Continued). Gas producers and their construction. Open hearth process.

13. Friday, December 8.

    Steel (Concluded). Bessemer process and its limitations. Physical properties, strength, and unit stresses of structural steel.

14. Friday, December 15.

    Paints. Corrosion of iron and steel. Composition of paints. Theory and application.

ZOOLOGY 4

MR. LAWRENCE

Revelations of Biological Research

1. Monday, January 8.

   Origin of Life on the Earth. Theories and beliefs. Protoplasm the physical basis of life. The cell. Reproduction.

2. Monday, January 15.

   Division of Labor. Tissues, organs, and systems. Specialization produces many types. Life tries many experiments.

3. Monday, January 22.

   Geographical Distribution. Definite habitats. Law of dispersion. Highways and barriers. Isolated groups.

4. Monday, January 29.

   The Effects of Environment upon Animal Life. Success or failure. Improvement or degeneracy. Factors involved.

5. Monday, February 5.

   Physiological Principles of Life. The chemistry of living things. Respiration, digestion, growth, enzyme action, etc. Osmosis.

Monday, February 12. No lecture.

6. Monday, February 19.

   Relationship of All Living Things. Observations of Aristotle. His methods forgotten. Revelations of the revival of the scientific method.

7. Monday, February 26.

   Modern Views about the Origin of Species. Lamarck, Darwin, and DeVries.

8. Monday, March 4.

   Mendel's Discoveries in Heredity. Not appreciated but forgotten. Rediscovered in 1900. Unit characters. Dominant and recessive characters. Mendel's Law.

9. Monday, March 11.

   The Followers of Mendel. A review of four decades of research in genetics.

10. Monday, March 18.

    Eugenics. The right of every child to be well born. Is the human race improving or degenerating?

11. Monday, March 25.

    Practical Value of Research in Genetics. New and better varieties. "New species?" What is in the future?

12. Monday, April 1.

The Balance of Nature. Always a struggle. Some win, others lose. Associations of animals.

13. Monday, April 8.

Endocrine Glands. Hormones the regulators of life processes. Man's control over their deficiencies.

14. Monday, April 15.

Effects of Civilization upon the Animal Life of the World. Extermination of valuable species. Introduction of species into new territory. Pest control. Domestication of animals.

Field Trip

The class in Zoology will be conducted on a field trip under the leadership of Mr. Lawrence. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

GEOLOGY 1

PROFESSOR HOWELL

Physical Geography

Lectures begin at 7.45 P. M.*

1. Tuesday, January 2.

The Waters and the Dry Lands of the Earth. Habitable lands and open oceans, frozen lands and ice-strewn seas.

2. Tuesday, January 9.

The Lands Where Men Can Live. The hunters' forests, the farmers' plains and valleys, and the herdsmen's hills and deserts.

3. Tuesday, January 16.

The Hidden Treasures of Mine and Sea. The ores, so essential to our civilization, and the fisheries, on which we must increasingly depend for food.

4. Tuesday, January 23.

North America, Our Own Rich and Fertile Continent. Its mountains, plains, deserts, woodlands, and tundras.

5. Tuesday, January 30.

Europe, the Continent of Peninsulas and Inland Seas. The influence of European geography on human history.

6. Tuesday, February 6.

Asia, the Vast Continent. Its tropical jungles, majestic mountain ranges, desert basins, plains, forests, and frozen tundras.

7. Tuesday, February 13.

Africa, Continent of Deserts and Rain Forests. The Sahara, the eastern plateaus, the Congo Basin jungles, and the dry lands to the south.

8. Tuesday, February 20.

Australia, the Island Continent. Its dry and barren interior and the more habitable lands surrounding it.

9. Tuesday, February 27.

South America, the Triangular Continent. How the tropical jungles of its northern base give way to the cold and windswept plains and mountains of its southern apex.

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* Please note the hour.

10. Tuesday, March 5.

    Antarctica, the Continent Covered With Ice. The last continent to be explored and utilized by men.

11. Tuesday, March 12.

    The Scattered Islands of the Seas. Their variety and growing importance to us.

12. Tuesday, March 19.

    The Arctic Ocean and its Frozen Islands. The home of the Esquimaux and the seal.

13. Tuesday, March 26.

    The Shallow Oceans and Their Teeming Life. The spacious pastures of the sea whose herds must feed our great-grandchildren.

14. Tuesday, April 2.

    The Vast, Cold, Dark, and Silent Deep Sea Basins. The silent, motionless abysses of the great oceans and their ooze-covered floors.

Field Trip

The class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

PHYSICS 2

PROFESSOR SEELY

Heat and Sound

Lectures begin at 8 P. M.

Heat

1. Wednesday, January 3.

    Energy shows itself only through matter. Vibrations in matter. Energy in atoms, in molecules, and in masses of matter. Changes in (a) temperature, (b) volume, (c) molecular arrangement.

2. Wednesday, January 10.

    Heat energy causes changes in temperature. Temperature sensation. Temperature measurements. Thermometers and thermometer scales.

3. Wednesday, January 17.

    Heat energy causes changes in volume. Coefficient of linear expansion. Charles' law. The absolute zero. Illustrations and applications to building, refrigeration, etc.

4. Wednesday, January 24.

    Heat energy causes changes in molecular structure. Latent heat of fusion. Specific heat. Applications to weather and climate.

5. Wednesday, January 31.

    How heat energy travels from place to place. Conduction, convection, and radiation. Radiant energy. Infra-red and ultra-violet waves. The solar constant.

6. Wednesday, February 7.

    Heat energy may be measured. The calorie and the British thermal unit. Transformation of energy and heat losses.

7. Wednesday, February 14.

    The mechanical energy equivalent of heat. Mechanical equivalent of heat. The laws of thermo-dynamics.

Sound

8. Wednesday, February 21.

   Vibrating bodies resting in a fluid tend to produce waves. Vibrating bodies. Simple harmonic motion. Transverse and logitudinal waves.

9. Wednesday, February 28.

   Air waves are the cause of sound sensation. Perception of sound. The ear. Limits of human hearing. Noise and hearing.

10. Wednesday, March 6.

    Sound waves have certain properties and behave in certain ways. Velocity. Reflection. Echoes. Whispering galleries. Resonance.

11. Wednesday, March 13.

    Properties and behavior of sound waves (concluded). Sympathetic vibrations. Interference. Beats. Harmony and discord.

12. Wednesday, March 20.

    Musical sounds are those which are pleasing to the ear. Pitch. Intensity or loudness. Quality or timbre. Doppler's principle. Overtones. Resonators.

13. Wednesday, March 27.

    Musical sounds (concluded). The musical scale. Melody, harmony, and rhythm.

14. Wednesday, April 3.

    Man has made and studied many musical instruments. Laws of vibrating strings. Nodes and segments. Vibrating columns of air.

MUSEUM TALKS

Monday evenings at 7 o'clock

This series comprises informal talks, given on Monday evenings in the Museum, illustrated by specimens.

PROFESSOR HOWELL

Rocks and Their Contents

Sept. 11. The Many Kinds of Rocks Which Form the Earth's Crust.
Sept. 18. The Minerals of Which These Different Rocks are Composed.
Sept. 25. How our Ores and Precious Stones Were Formed.
Oct. 2. Other Treasures Which are Hidden in the Rocks.
Oct. 9. Tales we can Read in the Stone Book of Life.
Oct. 16. Man's Trail Across the Hardened Sands of Time.

MR. HOPE

Animals of the Water

Oct. 23. Water as a Home.
Oct. 30. The Open Sea and Between the Tides.
Nov. 6. Life in the Ocean Depths.
Nov. 13. Life in Inland Streams.
Nov. 20. Life in Lakes and Ponds.
Nov. 27. Biologically Remarkable Bodies of Water; Bogs, Saline Pools, Thermal Springs and Subterranean Waters.

Mr. Lawrence

Animals of the Land

Dec. 4.	Animals That Dig into the Ground.
Dec. 11.	Animals of the Deserts.
Dec. 18.	Animals of the Mountains
Dec. 25.	No lecture.
Jan. 1.	No lecture.
Jan. 8.	Animals That Live in Forests.
Jan. 15.	Animals That Live in Trees.
Jan. 22.	Animals That Live in Open Fields.

Miss Borden

Animals of the Air

Jan. 29.	How Flight Became Possible: Many Failures Before Success.
Feb. 5.	Strong and Weak Fliers Among the Insects.
Feb. 12.	No Lecture.
Feb. 19.	Animals That Fly Only at Night.
Feb. 26.	Birds That Fly Over Salt Water.
Mar. 4.	Birds That Fly Over Fresh Water and Land.
Mar. 11.	Flights for Food, and Migrations.

Professor Kaiser

Great Groups of Plants

Mar. 18.	Flax, Coca, Quassia, Rue, Citron, Orange, Lemon.
Mar. 25.	Cashew, Mango, Poison Ivy, Holly. Bittersweet, Bladdernut, Maple.
Apr. 1.	Buckthorn, Jujube, New Jersey Tea, Grape, Virginia Creeper, Boston Ivy.
Apr. 8.	Ash, Lilac, Olive, Privet, Gentian, Pennywort, Buckbean.
Apr. 15.	Milkweed, Wax Plant, Carrion-flower, Dogbane, Oleander, Periwinkle.
Apr. 22.	Morning Glory, Dodder, Sweet Potato, Teak, Vervain, Heliotrope, Forget-me-not.

GENERAL SCHEDULE OF REGULAR LECTURES

Subjects of courses in each of the four successive years constituting a full term.

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles, Notation, Nomenclature.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

ZOOLOGY

1. Invertebrate Animals.
2. Vertebrate Animals.
3. Human Biology.
4. Principles of Animal Life.

BOTANY

1. Morphology.
2. Taxonomy.
3. Taxonomy (continued).
4. Physiology and Ecology.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

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BULLETIN

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BULLETIN
of the
WAGNER FREE INSTITUTE OF SCIENCE
PUBLISHED BY THE INSTITUTE
SYDNEY L. WRIGHT, *Editor*

Vol. 14 No. 4	Quarterly NOVEMBER, 1939	$1.00 per year Single numbers, 25 cents

A NEW CAMBRIAN ALGA FROM NEWFOUNDLAND

By BENJAMIN F. HOWELL, A.M., PH.D.

Although algae must have been numerous denizens of Cambrian seas, their fossilized remains are not abundant in Cambrian strata. Some Upper Cambrian limestones do contain single colonies, and even reefs, of calcareous algae, and nineteen non-calcareous species have been recorded from the Middle Cambrian Burgess and Stephen formations of British Columbia[1] and four have been reported from the Lower Cambrian Kinzers formation of Pennsylvania.[2] But the Burgess, Stephen, and Kinzers formations are exceptional in that they contain the remains of many organisms which lacked hard parts; and recognizable fossils of non-calcareous algae are so rarely found in other Cambrian formations that any discovery of a new species is worthy of record. When such a discovery is made in strata which are believed to be of very early Cambrian age, it takes on added interest; for, with the exception of the peculiar early Cambrian fossils belonging in the genus *Oldhamia*, which the writer believes to be the remains of algae, few such records of the marine plant life of such very ancient oceans have been found.[3]

A thick section of Cambrian rocks has recently been found cropping out in the vicinity of Rencontre East, on the southern coast of Newfoundland. Mr. D. E. White, who is preparing a description of this section for publication by the Department of Natural Resources of Newfoundland, has divided its strata into formations, the next to oldest of which, made up of arkosic conglomerates and sandstones, he proposes to call the Pools Cove Formation. From this formation he has collected a slab of reddish colored sandstone, one surface of which is covered with a thin layer of red, sandy shale. On this

[1] C. D. Walcott. Cambrian Geology and Paleontology, IV, no. 5—Middle Cambrian algae, Smithsonian Miscellaneous Collections, vol. 67, no. 5, 1919.

[2] C. E. Resser and B. F. Howell. Lower Cambrian *Olenellus* zone of the Appalachians, Bulletin of the Geological Society of America, vol. 49, 1938, pp. 209–210, pl. 1.

[3] R. Ruedemann. Paleozoic plankton of North America, Geological Society of America, Memoir 2, 1934, pp. 28–30.

layer of shale are impressions which are believed to have been made by the fronds of algae. Through the courtesy of Dr. A. K. Snelgrove, Government Geologist of Newfoundland, the writer has been permitted to describe these fossils here.

No other fossils have been found in the Pools Cove Formation; but Middle Cambrian fossils occur higher in the section; and, for this and other reasons, the bed from which the algal impressions were collected is believed to be of Early EoCambrian age.

All the imprints are believed to have been made by the fronds of a single new species, a red alga, which is described below.

CLASS: *Algae*
SUBCLASS: *Rhodophyceae*
FAMILY: *Rhodomelaceae*
Wahpia terranovica, new species

Thallus composed of slender stem and branches, as shown in the illustration. Both stem and branches appear to have been nearly, or quite, cylindrical in cross section. There is no evidence in the fossil as to whether they were hollow. They were, however, substantial enough to maintain their original thickness when buried, for there is no evidence that they were flattened in the process. None of the specimens includes the basal portion of the stem, so its character is not known.

At present the impressions made in the enclosing rock by the bodies of the plants are filled with crystals of calcite except for some parts from which the calcite has been dissolved away.

Our species has been placed in Walcott's genus, *Wahpia*, because of its resemblance to his species, *Wahpia insolens*, described from the famous Middle Cambrian fossil bed of the *Ogygopsis* zone of the Stephen Formation on Mount Stephen, British Columbia.[4] It differs from that species in that the angle of its branching is smaller, on the average, and in that its main branches, while they are less regularly arranged, bifurcate more times after leaving the stem. These differences may be more apparent than real, since we have only a few examples of each species on which to base our comparisons, and the form of the thallus may have been much the same in the two. But, since the Newfoundland plant lived some tens of millions of years before its British Columbian relative, the two were almost certainly specifically distinct.

The thallus of the various species of *Wahpia* must have been less easily flattened than were the bodies of most kinds of non-calcareous algae; for, whereas fossils of such plants are usually found as thin films on the bedding surfaces of their enclosing strata, the thallus of *Wahpia terranovica* retained its form during burial; and Walcott remarks of the specimens of *Wahpia mimica*, another species, which he described from the Burgess Shale member of the Stephen Formation of British Columbia, that they "left a strong impression on the shale."[5]

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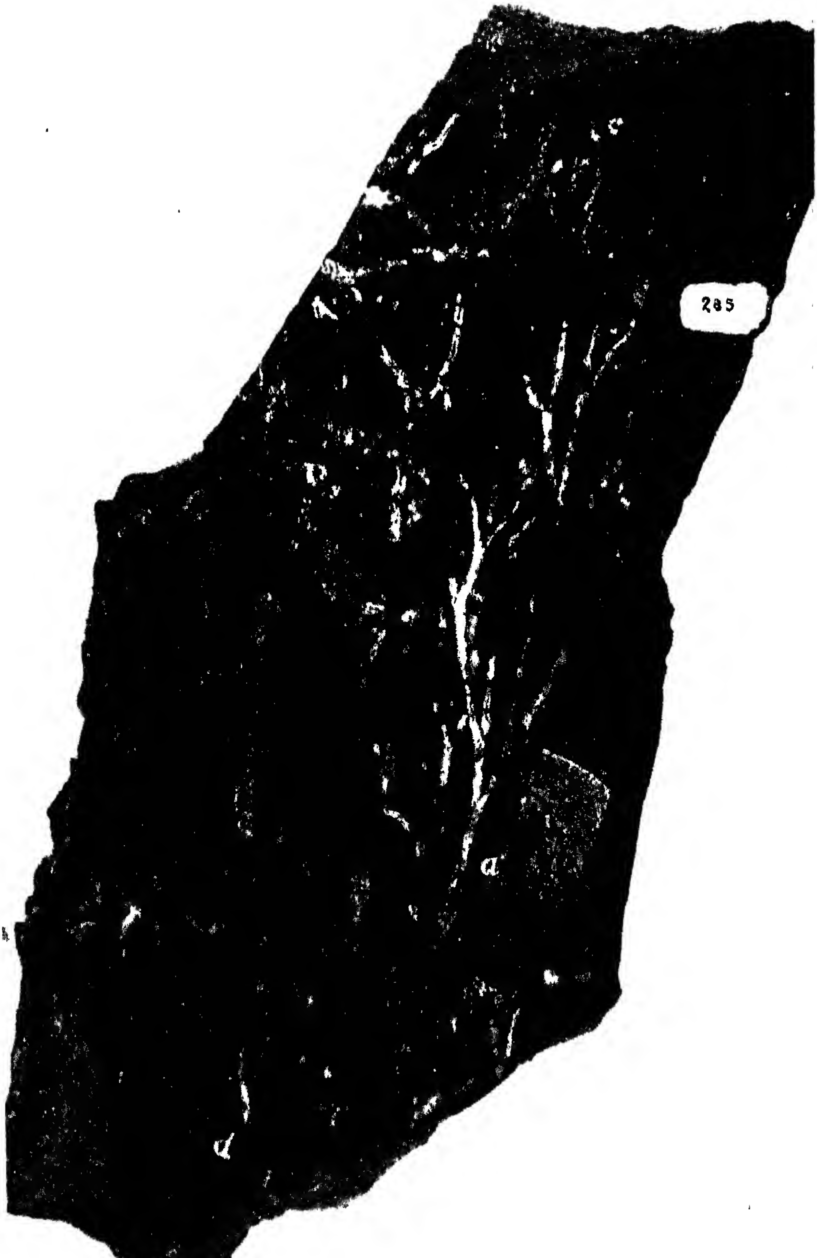
[4] Walcott, C. D. Op. cit., p. 240, pl. 57, fig. 1, 1a.
[5] Walcott, C. D. Op. cit., p. 240.

The type specimens of *Wahpia terranovica* were collected by Mr. D. E. White from a bed about 2000 feet above the base of the Lower Cambrian Pools Cove Formation in the first cove west of Bay d'East Head, in the Rencontre East area, on the southern coast of Newfoundland. The holotype is no. 52081 a, and the paratypes are nos. 52081 b–d, in the paleontological collection of Princeton University.

Walcott placed the genus, *Wahpia*, in the Rhodomelaceae because the fossils on which he based it resembled in form the thalli of *Ceramium*, and of other similar living genera, such as *Ahnfeldtia* and *Cystoclonium*.

EXPLANATION OF PLATE

Holotype (a) and paratypes (b-d) of *Wahpia terranovica* Howell from the Lower Cambrian Pools Cove Formation of the Rencontre East area, southern Newfoundland. Natural size.



HOWELL-A NEW CAMBRIAN ALGA FROM NEWFOUNDLAND

BULLETIN

of the

WAGNER FREE INSTITUTE OF SCIENCE

PUBLISHED BY THE INSTITUTE

SYDNEY L. WRIGHT, *Editor*

Vol. 15 No. 1	Quarterly FEBRUARY, 1940	$1.00 per year Single numbers, 25 cents

A NEW SPONGE FROM THE CAMBRIAN OF WYOMING

By B. F. HOWELL and F. B. VAN HOUTEN

Dr. Max Demorest, of the University of North Dakota, and Mr. and Mrs. William Paton, of Shell, Wyoming, have kindly presented to Princeton University six fragments of sandstone from the Upper Cambrian "Gallatin" Formation of the Bighorn Mountains of Wyoming, which are full of small columnar structures. Within and around these columns are many sponge spicules. Since sponges are rare in Cambrian rocks and these specimens from the Bighorns are so unusual in their form, they merit description.

As shown in the figures here presented, these sponges are preserved as short columns, an eighth of an inch to an inch in diameter and a quarter of an inch to an inch in height, which vary from circular to elongate oval in cross-section. These columns are composed partly of small grains of quartz sand and partly of siliceous spicules of the various shapes characteristic of sponges of the Class Silicispongiae and the Subclass Hexactinellida. Particles of glauconite as well as quartz, and many scattered spicules, fill the inter-columnar spaces.

By grinding and polishing perpendicular sections of these specimens and dissolving away some of the calcareous cement, it has been possible to study the relations of the individual cylindrical columns to each other and to determine the shape of some of the spicules.

Explanation of Plates

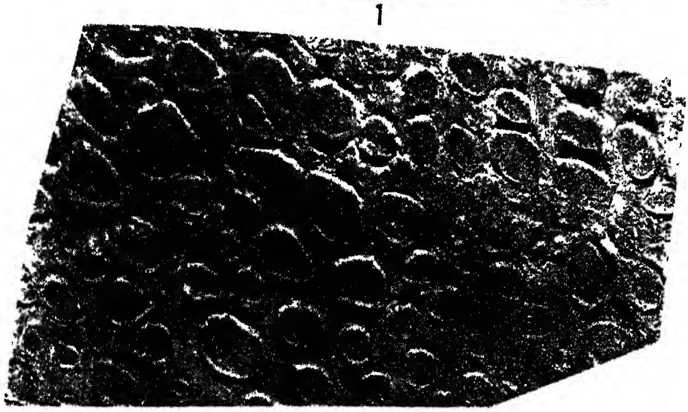
Plate I

Fig. 1: *Multivasculatus ovatus* Howell and Van Houten. Cross-section of part of holotype colony. × 1. No. 52229a, Princeton Univ. "Gallatin" Formation, Upper Cambrian. Clear Creek, about 6 miles west of Buffalo, Wyoming.

Fig. 2: *Multivasculatus ovatus* Howell and Van Houten. Top view of part of holotype colony. × 1.

Fig. 3: *Multivasculatus ovatus* Howell and Van Houten. Top view of part of holotype colony. × 6. Note the rod-shaped spicules surrounding the columns.

1



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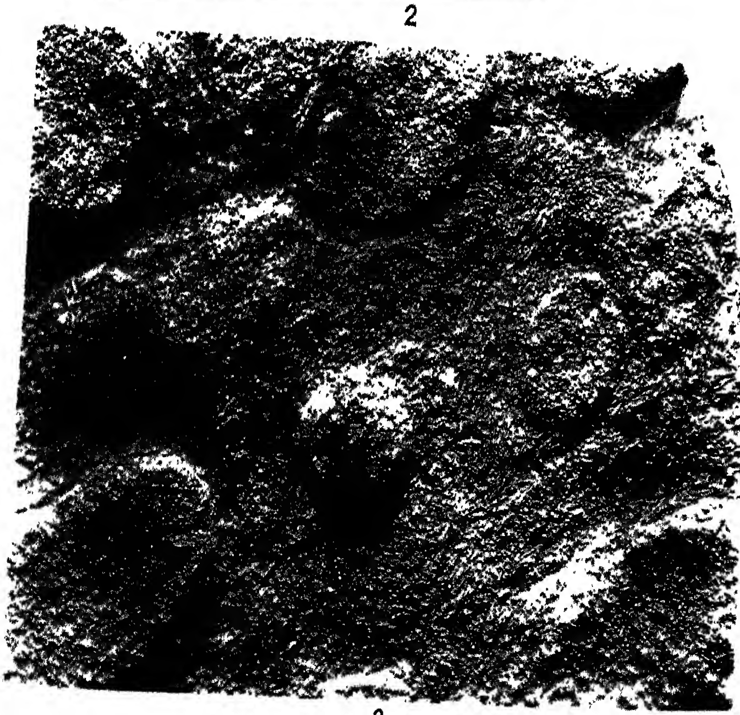


3

The columns in each specimen project upward from a definite basal layer, which, although undulating, is, in general, parallel to the bedding of the reddish sandstone in which the fossils are preserved. As the columns are lighter in color than the matrix, their outlines are clearly visible on a polished surface, and it can be seen that they increase a little in diameter toward their summits, so that the shape is that of a truncated cone. The constricted end of each column rises from the basal layer, which is the same color as the columns themselves, and which extends as a sheet beneath them. This layer varies in thickness from one-sixteenth to one-half of an inch. It was presumably a mat of living cells, connecting and supporting the separate columns. Spicules are rare in this basal layer, and they may have been rare in, or absent from, that part of the living sponge.

If this interpretation is correct, the sponges were compound, with many separate oscula, each opening upward from a bluntly vase-shaped branch, which rose from a basal sheet.

Unfortunately all of the sandstone fragments were found detached from their parent beds, and their original upper surfaces cannot now be definitely determined. The interpretation of the form of the sponge colonies which is given above is based on the assumption that the surface from which the columns have been left projecting by the action of the agents of weathering was the top of the slab in each instance. It is difficult to conceive either of the sponges as having grown in any other position or of the columns having been brought out in relief in any other place than on the upper sides of the slabs.

There is much difference in the size and form of the cross-sections of the columns in these specimens; but the variation in each slab would seem to indicate the reference of all to a single species.

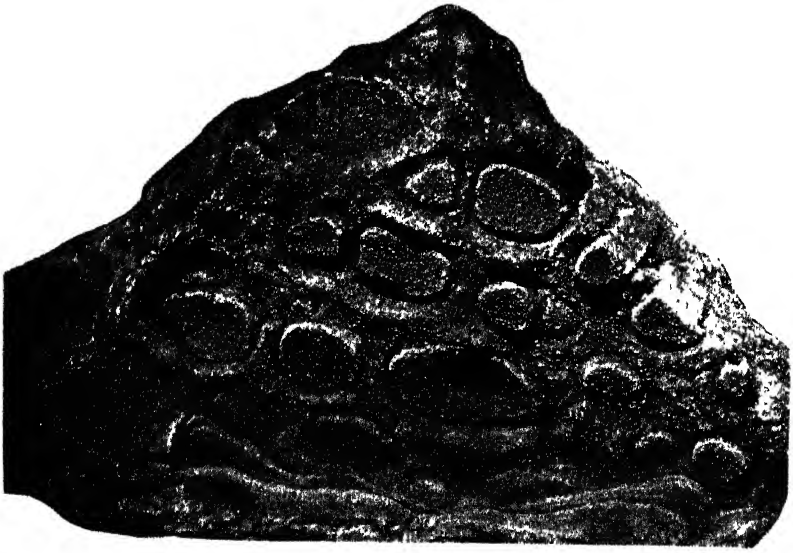
The individual spicules which have been secured by dissolving away the calcareous matrix, or which have been exposed by weathering, belong to the three general types shown in the illustrations. One of these is a six-rayed form, in some examples of which the rays are all of the same length and diameter, while in others two of the rays, lying opposite each other, are reduced to mere knobs. The second form is a curved rod, with a papillose surface, at one end of which are five much smaller rays. The spicule is thus six-rayed, but has one ray many times thicker and longer than the others. The third form is a straight rod, of the same diameter as the arms of the six-rayed spicules of the first type, though somewhat longer.

Of these three kinds of spicules, the first type of six-rayed ones and the curved rods are found within the columns themselves, while the straight rods lie in the matrix just outside of the columns. It therefore seems probable that the six-rayed and the curved spicules were parts of the internal skeletons of the vase-like branches of the colony, while the straight ones projected out-

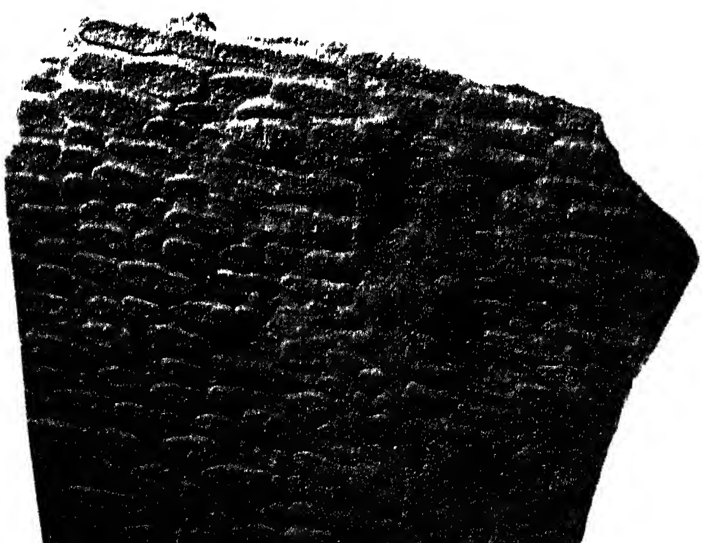
PLATE II

FIG. 1: *Multivasculatus ovatus* Howell and Van Houten. Part of paratype colony. $\times \frac{3}{5}$. No. 52232, Princeton Univ. "Gallatin" Formation, Upper Cambrian, southwestern side of Walker Mountain, Dayton Quadrangle, Wyoming.

FIG. 2: *Multivasculatus ovatus* Howell and Van Houten. Part of paratype colony. $\times \frac{1}{2}$. No. 52230a, Princeton Univ. "Gallatin" Formation, Upper Cambrian, northern side of Wolf Creek, Dayton Quadrangle, Wyoming.



1



2

PLATE III

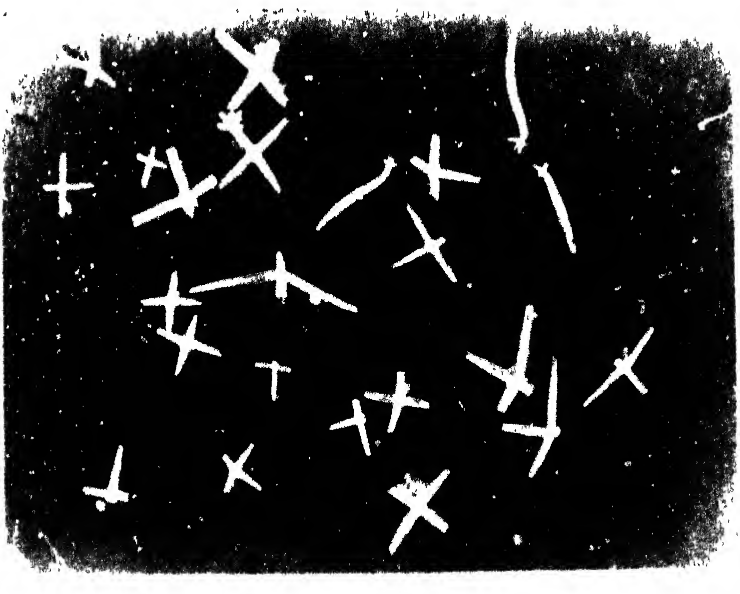
FIGS. 1–3: *Multivasculatus ovatus* Howell and Van Houten. Spicules from holotype colony. × 40. No. 52229b, Princeton Univ.

FIG. 4: *Multivasculatus ovatus* Howell and Van Houten. Spicules from holotype colony. × 15. No. 52229b, Princeton Univ.

1

2

3



4

dents of present-day marine faunas.* Although, as noted above, it presumably does not belong in the Family Hyalonematidae, it seems best for the present to classify and describe our new species as follows, as the genotype of a new genus, which we call *Multivasculatus*.

PHYLUM PORIFERA

CLASS: *Silicispongiae*

SUBCLASS: *Hexactinellida*

ORDER: *Lyssacina*

SUBORDER: *Amphidiscophora*

FAMILY: *Hyalonematidae*

Multivasculatus ovatus, new genus and new species

Pl. I, figs. 1–3; pl. II, figs. 1, 2; pl. III, figs. 1–4

A siliceous sponge, apparently colonial, with a basal encrusting layer, one-sixteenth to one-half an inch thick, from which rose many vase-shaped branches, an eighth of an inch to an inch in diameter, a quarter of an inch to an inch in height, more or less oval in cross-section, and each with a single osculum. Skeletons of the branches made up of three kinds of spicules: six-rayed spicules, in some of which the two rays of one of the three axes are reduced to tiny knobs or are possibly absent; curved rods with papillose surfaces and five very much smaller rays at one end; and straight rods. The six-rayed spicules in which the rays of one axis are not developed and the straight rods are the more abundant, but the curved rods are not rare. Few, if any, spicules appear to have been present in the basal layer from which the branches rose. The six-rayed and curved spicules appear to have made up the supporting internal skeletons of the branches, and the straight rods probably projected outward from the upper parts of the branches.

Location of types: The holotype is no. 52229a in the paleontological collection of Princeton University. Loose spicules that were extracted from the holotype by dissolving the matrix away with hydrochloric acid are no. 52229b in the same collection, and broken pieces of the columns and matrix of the same colony, treated with hydrochloric acid so that the spicules in place can be more easily seen, are nos. 52229c–f. Paratypes are nos. 52230a–c, 52231, and 52232.

Age and locality: The holotype is from a loose block of the Upper Cambrian "Gallatin" Formation on the eastern bank of Clear Creek, about 6 miles up the stream from Buffalo, Wyoming. Paratype 52230 is from the "Gallatin" Formation on the northern side of Wolf Creek, in the Dayton Quad-

* See The Cambridge Natural History, vol. 1, 1906, pp. 170, 204, and 205, for figures of *Halichondria*, *Hyalonema*, and *Pheronema*.

rangle, Wyoming. The exact locality and formation from which paratype 52231 was collected are not known; but it was probably secured from the "Gallatin" Formation as it came from the same general region as the other specimens. Paratype 52232 is from the "Gallatin" Formation on the southwestern side of Walker Mountain, in the Dayton Quadrangle, Wyoming.

Specimens 52229, 52230, and 52232 were collected by Dr. Demorest. Specimen 52231 was collected by Mr. William Paton and was presented by Mr. and Mrs. Paton through Dr. Demorest. The specimens presented by Dr. Demorest were secured in the course of field studies which were financed in part by the Department of Geology of Princeton University.

BULLETIN

of the

WAGNER FREE INSTITUTE OF SCIENCE

PUBLISHED BY THE INSTITUTE

SYDNEY L. WRIGHT, *Editor*

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A SYNOPSIS OF FOUR LECTURES ON ATOMIC NUCLEI AND ATOMIC TRANSMUTATIONS

(Delivered under The Richard B. Westbrook Free Lectureship, 1940)

By KENNETH T. BAINBRIDGE, S.M., PH.D.
Associate Professor of Physics, Harvard University

LECTURE I

Stable Atomic Nuclei

Modern theories of the atom and the electrical nature of matter made great advances as a consequence of studies on the conduction of electricity in gases. The discoveries of X-rays (W. Roentgen, 1895), electrons (J. J. Thomson, 1897) and the isotopes of non-radioactive elements (F. W. Aston, 1919) were the most important developments. [Demonstration of a replica of J. J. Thomson's cathode ray and positive ray tube.] The nature of the charged rays can be determined by their deflection in magnetic and electric fields. [Demonstration of the deflection of a beam of electrons or cathode rays in a magnetic field.] Thomson showed that electrons were negatively charged particles with a definite ratio of charge to mass irrespective of their manner of release from gases or metals of any kind. The electron is a universal constituent of matter, light compared to the atom.

Atoms are electrically neutral, and contain a central core, the nucleus, positively charged and surrounded by electrons. The net positive charge of a nucleus determines the number of electron satellites and the chemical properties of an atom. The positive ions, left behind after loss of an electron, are not all identical nor are the positive fragments of the atoms of a single element uniform in their charge to mass ratios. The analysis of positive rays was first accomplished by Aston.

A ribbon-like beam of ions produced in an electric discharge tube is passed through an electric field and then through a magnetic field. Beams of ions of different mass to charge ratio are thereby dispersed into a spectrum and

impinge on a photographic plate. The record obtained Aston termed a mass-spectrum. Tin shows ten lines, mercury seven lines, on the plate. The ten lines of tin correspond to isotopes of tin, chemically identical atoms, differing in mass and nuclear structure, occupying the same place in the periodic table.

Instruments for the analysis of positive ions are called mass-spectrographs. Their functions are:

1. The determination of the nuclear types of an element.
2. The measurement of the relative abundance of the isotopes of an element.
3. The accurate determination of the masses of atoms.

One kind of mass-spectrographs is particularly well suited for mass measurements recorded on photographic plates, another for measurements of the relative abundance of isotopes by electrical means. Both types of instrument have been useful for the study of the isotopic constitution of the elements. Records of germanium, mercury and uranium were shown.

The results of the three major applications of a mass-spectrograph lead to the physical determination of the chemical combining weight of atoms.

Mass-spectrum analyses of uranium and lead are valuable in determining the age of minerals. Uranium of atomic weight 238 disintegrates spontaneously and finally changes into lead of atomic weight 206. One part of lead to ten of uranium in an unaltered mineral indicates an age of approximately 900 million years if all the lead has been produced from the uranium. The mass-spectrograph can tell how much of the lead in a mineral has come from the slow breakdown of uranium. These measurements provide the most accurate figure for the age of the earth.

The accurate measurements of atomic masses tell how firmly the components of nuclei are bound together. Nuclei are complex structures. Hydrogen is the simplest, uranium the most complex. The component particles are held together by tremendous forces. Work must be done to separate the constituents. On the basis of the Einstein theory of the equivalence of mass and energy, mass was released in the formation of the atomic nuclei. The amount of mass lost in this way can be measured by the mass-spectrograph. Comparison of these measurements with the results of disintegration experiments has given the best experimental test of the equivalence of mass and energy and shows agreement with Einstein's predictions. The fact that in the building of heavier elements from lighter ones energy is released, accounts for the energy of the sun and other stars.

[Lantern slides were used to illustrate the several types of mass-spectrographs and the records obtained by their use.]

LECTURE II

Radioactive Atomic Nuclei

The phenomenon of radioactivity, or the spontaneous disintegration of certain elements, was discovered by Becquerel in 1896. Salts of uranium were found to emit radiations which could penetrate paper or metal foil and

blacken a photographic plate. The Curies noticed greater activity from uranium ore than from an equal amount of uranium. This led to the discovery of radium and polonium. About forty types of naturally radioactive substances are known.

The radiations from radioactive substances were first designated as alpha, beta, and gamma rays. Radiations in their passage through matter leave a trail of ions which produce measurable effects. The Geiger-Mueller tube counter amplifies the ionization effects and records the passage of an ionizing particle as an audible click in a loud-speaker.

The Wilson cloud chamber, in which visible water droplets are condensed out on the invisible ions produced by an ionizing radiation, permits visual or photographic observation of the trail or path in air of individual particles. It is a scientific instrument unexcelled in the number and importance of the advances achieved by its use. [Demonstration of the paths of alpha-particles from polonium projected on the screen from a Wilson chamber.]

Alpha rays have very little penetrating power as they can be stopped by thin cellophane. [Demonstration of the absorption of alpha rays which entered a Geiger-Mueller counter.] Alpha rays are positively charged helium nuclei emitted at speeds of about 10,000 miles a second.

Beta rays are negative electrons traveling at speeds approaching the velocity of light, 186,000 miles a second. The beta rays penetrate cellophane easily but are stopped by a thin sheet of metal. [Demonstration.]

Gamma rays are similar in nature to X-rays and light. Their penetrating power is so great that cellophane and an aluminum sheet do not absorb them appreciably. Thick lead absorbs a fraction of them. [Demonstration.] Gamma rays do not produce ionization effects directly but release electrons from matter in a variety of ways.

The emission of an alpha-particle or a beta-particle signals the disintegration of a nucleus and its transformation to another type. The amount of a radioactive substance present decreases with time as it transforms. Each radioactive substance is characterized by a half-life period during which one-half of the amount initially present decays. In the next period one-half of what was left has gone, and so on. [Demonstration of the decay of thoron, which has a period of 54½ seconds.] The half-life periods of radioactive substances range from 16 billion years to one ten-millionth of a second. Radium has a period of 1590 years.

One of the great triumphs of the physical sciences is the Rutherford-Bohr nuclear model of the atom which serves to correlate and illuminate phenomena of all kinds from the vast provinces of chemistry and physics. Rutherford was led in 1911 to propose the nuclear atom model as a result of experiments in which alpha-particles were sent through gold leaf and silver foil. Occasionally an alpha-particle passed close to a gold or silver nucleus and was deflected through a large angle. To satisfy all the observed facts, mechanical laws demanded the presence of a small charged central nucleus for the gold atom, the silver atom, and the atoms of all chemical elements.

Later, in 1919, in extended measurements made on the alpha-particle bombardment of nitrogen, the occasional appearance of hydrogen nuclei or

protons was observed. This phenomenon was interpreted as the result of the transmutation of nitrogen into oxygen. Wilson chamber photographs allowed a detailed study of this type of synthesis of oxygen and hydrogen from nitrogen and helium. The first reaction of the new nuclear chemistry had been achieved.

A very penetrating radiation, apparently more energetic than those already known, was observed when beryllium, boron, and lithium were bombarded by alpha-particles. (W. Bothe and H. Becker, 1930.) The new radiation could project protons from substances containing hydrogen. (I. Curie-Joliot and F. Joliot, 1932.) This radiation was found by Chadwick to comprise neutral particles, very nearly of the same mass as hydrogen, which were termed neutrons.

In the early transmutation experiments, using radiations from naturally radioactive sources, the efficiency of transmutation was poor because of the relatively low energy of the bombarding particles which must surmount or penetrate the region of repulsive forces surrounding atomic nuclei. It was believed that more transmutations would result if higher energy particles in greater numbers could be made available. A great incentive to the development of laboratory methods of producing high speed atomic projectiles was provided by the theoretical prediction that protons would be thousands of times more effective than alpha-particles for the production of atomic transmutations. Since no natural source of protons is known to exist, proton beams must be produced by laboratory methods.

The experiments of Cockcroft and Walton (1932) in which protons produced the disintegration of lithium into two helium atoms, were the first to use hydrogen projectiles speeded up by laboratory methods to bring about atomic transmutation.

[All of the topics discussed were illustrated by lantern slides.]

Lecture III

The Manufacture of Radioactive Substances

In summarizing the previous lectures emphasis was placed on the Rutherford-Bohr model of the atom and the significance of the atomic number, a measure of the net positive charge on the nucleus which determines the number of external electron satellites and thereby defines the chemical properties of an atom.

Transmutation is alteration of the nucleus. The nucleus of a silver atom contains 47 positively charged particles, protons. In addition, one type of silver atom has 60 neutral particles or neutrons. The heavier isotope of silver contains 62 neutrons. Two possible types of alteration of the nucleus are, first, the addition of a proton, which would change a silver atom to an atom of cadmium and, second, the addition of a neutron to a silver atom, which would result in silver of higher atomic weight, possibly unstable, as silver of this weight is not found to occur naturally.

The addition of a neutron to the nucleus of one isotope of silver can be carried out by relatively simple means. A source of neutrons is provided by

the bombardment of beryllium with the alpha-particles from radium emanation and its products. Some of the alpha-particles combine with the beryllium nuclei to form carbon and high speed neutrons. The neutrons are slowed down by impact with the hydrogen in water (E. Fermi, 1934) to a point where they are readily captured by the silver nuclei. The neutrons have no charge and therefore are not repulsed by the positively charged silver nuclei. After a minute's bombardment the silver coins are found to be radioactive, that is, they emit negative electrons and change to cadmium with a half-life period of 22 seconds. [Demonstration of the production of radioactive silver by bombardment of silver coins with slow neutrons. The radioactivity was indicated by a Geiger-Mueller counter.]

Induced or artificial radioactivity was discovered in 1934 by F. Joliot and I. Curie-Joliot. There are 88 elements found in the earth's crust and about 280 known stable types of nuclei or atomic species. From these, approximately 400 new artificially radioactive types have been made. The production of atomic transmutations depended at first on using the high speed alpha-particles from radium or its products. Radium is very costly, one million dollars an ounce.

The production of high speed atomic projectiles by laboratory methods was developed at several laboratories. Lightning was an obvious source of great electrical forces (Brasch and Lange). Transformers in special circuits to multiply the output voltage have been used successfully (Cockcroft and Walton). Impulse generators or artificial lightning circuits were applied to speed up ions of helium and hydrogen (Kirchner). Many large Van de Graaff generators have been built as high as four or five story buildings. Electric charges are carried up to an insulated electrode by a belt. Ions of the desired atomic projectile are formed at this end of a long evacuated tube in which electrical forces act to push the ions through the tube at increasing speed until they reach the ground end where the material under bombardment may be placed. Electrons may also be accelerated for the creation of gamma rays.

The Lawrence cyclotron is unexcelled for the production of very high energy atomic projectiles and for the manufacture of radioactive substances by their use. The cyclotron is distinguished from other methods of attaining high speed projectiles by two novel features. First, the ions are not speeded down a long tube, but are forced to follow a spiral path in a flat, hollow, evacuated chamber several feet in diameter. Secondly, the ions do not achieve their final speed in one step, but, through high voltage electrical currents alternating at high frequency, receive 30 to 200 individual small pushes whose total effect may greatly exceed the maximum obtainable by any of the one push methods. [Here followed a detailed illustrated description of the 85-ton Harvard University cyclotron and its mode of operation.]

This cyclotron, second in transmuting power to the 250-ton instrument at the University of California, can produce a directed beam of alpha-particles of four times the energy of those from radium, and equal in number to the total number emitted in all directions from 40 grams of radium.

The cyclotron can produce more than 200,000 times as many neutrons as are produced from the older type of source, one gram of radium mixed with

beryllium. Neutrons have important applications in medicine, biology and physics.

The cyclotron is unsurpassed in the manufacture of induced radioactive substances. The radioactive types of longer life provide a tool of great value for studying the behavior of selected elements in chemical substances and biological materials. The addition of a minute amount of a cyclotron-manufactured radioactive element to large amounts of its chemically identical stable twin enables an investigator to label or tag the element or one of its compounds and so trace the distribution of the labeled substance, for example, after assimilation in the human body.

Such experiments have made use of radioactive zinc in the study of insulin, iodine in the study of the thyroid gland, carbon in the study of lactic acid metabolism, phosphorus and its distribution in the body, iron compounds and their efficacy in the treatment of anemia. Phosphorus and neutron radiation are being developed for use as therapeutic agents. [Demonstration of the disintegration of radioactive phosphorus and zinc made by the cyclotron.]

Some elements non-existent in the earth's crust can be manufactured in their radioactive forms by the cyclotron. [Demonstration of the radioactive element number 43 produced from molybdenum.]

[Lantern slides were used to illustrate the topics discussed.]

Lecture IV

High Energy Phenomena

The hope of obtaining atomic energy in useful amounts rose above the realm of pure speculation with the discovery, during the past year, of a new type of atomic transmutation, the fission of uranium. The capture of a fast neutron by uranium 238, or of a slow neutron by uranium 235, results in the splitting or fission of the uranium into two parts which are released with much greater energy than that available from any other known process of transmutation. Approximately one-tenth percent of the mass of the uranium is changed into energy in the cataclysmic break-up which follows the capture of a neutron. The fission of uranium is so violent that, in addition to the two main products, which are themselves radioactive, three or four neutrons on the average are released also. If these neutrons could be efficiently applied to the production of more fissions, which in turn would release more neutrons, a rapidly increasing number of disintegrations would occur which, if uncontrolled, would be explosive in nature. Simple methods are known for the control of the fission process.

There are several difficulties in the way of securing useful amounts of energy from the fission of uranium. The fast neutrons necessary to produce fission of uranium 238 have high penetrating power, and huge masses of uranium would be necessary to capture enough of them to provide a regenerative action. Fast neutrons are more likely to lose their energy in scattering collisions than to produce fission. Once the neutron energy has been reduced below a certain threshold value for fission effects, another process takes place in which the neutrons are absorbed without large energy yields. This ab-

sorption occurs before the neutrons are low enough in energy to be "slow neutrons," which could produce fission effects in the nuclei of the lighter isotope, uranium 235.

If uranium 235 were available in concentrated form (uranium 238 is about 139 times more abundant in the natural substance), then theory indicates that a regenerative action could take place with the release of large amounts of energy. Pound for pound the uranium 235 would represent available energy approximately two million times greater than that released in burning coal. The separation in quantity of uranium 235 from 238 has not been accomplished, the nearest approach being a yield of one two-hundred thousandth of a pound per day at an expense which does not at present promise any economic gain.

The prospects for producing concentrated fuel of economic value are certainly not good, although the phenomenon of uranium fission represents the most recent advance and closest approach to the solution of the problem. Regenerative chain reactions cannot be ruled out as a possibility.

"The subject of cosmic rays is unique in modern physics for the minuteness of the phenomena, the delicacy of the observations, the adventurous excursions of the observers, the subtlety of the analysis, and the grandeur of the inferences" (K. K. Darrow).

Only the briefest account can be given of this fascinating field of physics, and only a few of the results obtained by leading workers can be described. The crucial experiment in the discovery of cosmic rays was made by Hess in 1911. He carried instruments up in a balloon and found that a very penetrating radiation, detectable with difficulty at the earth's surface, increased in intensity with increased height above the earth. That the new radiation did not originate in the earth, but came from outside the earth, was confirmed by later experiments.

Cosmic rays comprise radiation with energies transcending any released in nuclear reactions studied in laboratories, and more penetrating than any from radioactive substances. Among radiations from the latter substances are particles with 8,000,000 units of energy. Cyclotrons speed atomic projectiles to 50,000,000 units of energy. The fission of uranium releases 160,000,000 units. Cosmic rays have an energy of 1,000,000,000 units on the average, and some few may have one million times this amount.

In earlier lectures it was shown that positive particles are deflected one way in a magnetic field, and negative particles are deflected in the opposite direction. T. H. Johnson has used the magnetic field of the earth to study the nature of the primary cosmic ray particles. The fact that more are entering the earth from the west than from the east indicates in one group of the primaries a preponderance of positively charged corpuscles.

The positive electron was discovered by C. D. Anderson in 1932 from an examination of the curvature and density of the trails of cosmic ray particles in a Wilson cloud chamber. Now the positive electrons can be obtained in quantity in the laboratory as products of the disintegration of induced radioactive substances.

Cosmic rays may be classified in two divisions, a very penetrating radiation, and a "soft" or less penetrating radiation which has been identified as electrons of high energy. Swann and Montgomery showed that the penetrating rays were not protons. Anderson showed that they could not be electrons. Street and Stevenson obtained Wilson cloud chamber pictures of the penetrating rays which gave the first quantitative measurements of the mesons which comprise the penetrating corpuscular cosmic radiation. The meson is intermediate in mass between the electron and the proton and occurs with positive or negative charge. The existence of the new particle, which has been abundantly confirmed by other physicists, was predicted by Yukawa in his studies of the theory of binding forces of atomic nuclei.

Mesons are radioactive. A Wilson cloud chamber photograph of the disintegration of a meson obtained by Williams was shown.

A cosmic ray shower is the production of a large number of ionizing rays from the absorption of a single ionizing or non-ionizing ray. The production of a shower is a cascade process, the production of an electron pair accompanied by radiation which in turn produces more electrons and photons. Showers are produced by the less penetrating cosmic rays, no showers of this type being produced by mesons.

Cosmic ray bursts are very dense showers produced over an extensive area. Bursts involve the release of energy as great as a million times the average energy of individual cosmic rays, and greater than the energy available from the complete annihilation of uranium.

[Wilson chamber pictures were shown of cosmic rays, showers, and bursts photographed by Street, Stevenson, Anderson, Brode, Blackett, and Fussell.]

The Wagner Free Institute of Science

BULLETIN
of the
WAGNER FREE INSTITUTE OF SCIENCE
PUBLISHED BY THE INSTITUTE

SYDNEY L. WRIGHT, *Editor*

Vol. 15 No. 3 | Quarterly August, 1940 | $1.00 per year Single numbers, 25 cents

WAGNER FREE INSTITUTE OF SCIENCE

HISTORY

The Wagner Free Institute of Science was founded in 1847 by William Wagner, a citizen of Philadelphia.

In his early life William Wagner became associated with Stephen Girard in the extension of Girard's mercantile business. While in Girard's employ he had the opportunity to visit foreign countries, and being interested in scientific pursuits, he made a study of scientific institutions abroad and collected natural history specimens which afterward formed the nucleus for the collections in the museum of the Institute.

The Institute, itself, had its inception in a series of free lectures delivered by Professor Wagner in his home. These lectures, begun in 1847, were continued until 1855 when the Institute was incorporated by act of legislature.

A large measure of credit is due Mrs. Louisa Binney Wagner, Professor Wagner's wife, for sympathy, understanding and active coöperation in the early days of the founding of the Institute.

In 1855 a faculty was appointed and the work was continued in a new location at 13th and Spring Garden Streets, the City of Philadelphia giving permission for the use of Commissioners' Hall. Some years later Professor Wagner decided to erect a building on the present site at Seventeenth Street and Montgomery Avenue. This building was completed in 1865 and occupied immediately.

William Wagner died in 1885 and the management of the Institute was transferred to a Board of Trustees.

In 1901 a wing was added to the building for the use of a branch of the Free Library of Philadelphia.

INSTRUCTION

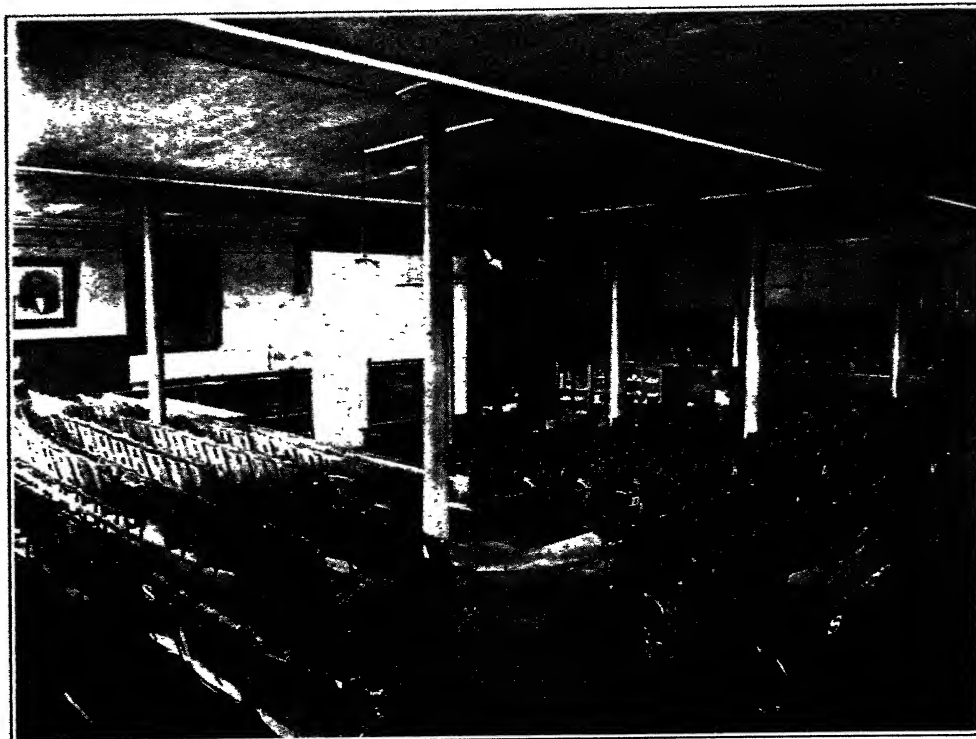
Lectures and Class-Work

Instruction at the Wagner Free Institute of Science is conducted by means of lectures supplemented by class work. There are no tuition fees.

Persons may attend lectures without registering for the classes if they so desire. Those registering for the classes are required to hand in a weekly paper and are admitted to an examination at the end of the term. Those persons successfully passing the examination are awarded certificates for the year's work.

There are seven courses of scientific lectures covering a period of fourteen weeks each for four years. On the successful completion of four years' work a Full Term Certificate is awarded.

The closing of each lecture season is marked by Commencement Exercises.



Auditorium

Museum

Museum

The Institute maintains a natural history museum containing more than 21,000 specimens illustrating the various branches of natural science.

The collections are arranged especially for study. The museum is open to visitors on Wednesday and Saturday afternoons from 1 P.M. until 4 P.M., except legal holidays.

On each Monday evening at 7 P.M., from September to May, a "Museum Talk" is delivered in the museum, the speaker using the specimens in the museum to illustrate the lecture.

Teachers and students desiring to use the museum for special studies will be admitted upon application at the office.

Libraries

The Reference Library of the Institute contains over 25,000 bound volumes and approximately 150,000 pamphlets on scientific subjects, classified and arranged for ready reference. There are also many foreign and domestic periodicals on file. The library is open to the public as well as to students from 10 A.M. to 9 P.M., Monday through Friday. Saturday, 10 A.M. to 5 P.M.

The Free Library of Philadelphia maintains a branch library in the building, known as the Wagner Institute Branch, from which books may be taken out under the rules of the Free Library.

Publications

The publications of the Institute consist of three series:

Transactions: begun in 1885 and discontinued in 1927.

Publications: succeeding the Transactions. These Publications are issued at irregular intervals.

Bulletin: issued quarterly.

SPECIAL LECTURES

Westbrook Free Lectureship

The Westbrook Free Lectureship is supported by the income from an endowment provided by Dr. Richard Brodhead Westbrook and his wife, Dr. Henrietta Payne Westbrook. The lectureship was established in 1912 and provides for one course of lectures each year. These lectures cover a wide range of topics and a list of those so far given may be found on page 43.

FANNIE FRANK LEFFMANN MEMORIAL LECTURESHIP

The income of a fund given by Dr. Henry Leffmann is applied to occasional special lectures under the Memorial Lectureship. These lectures are popular in character.

The *Philadelphia Natural History Society* is affiliated with the Institute and holds meetings on the third Thursday of each month from October to May.

RESEARCH

The Institute has carried on research work since 1885 in various departments of science. Results of research have been published from time to time in the Transactions, Publications and Bulletin.

The Institute is also the recipient of the income from two funds established by Dr. Henry Leffmann. This income is devoted to research in chemistry.

CERTIFICATES AWARDED AT CLOSING EXERCISES, MAY 15, 1940

FULL TERM CERTIFICATES

BOTANY
John G. Hope
Carroll R. McDonnell

ENGINEERING
George W. Baker
John M. Bley
Joseph S. Ferringo
L. Gilbert Obermiller

ORGANIC CHEMISTRY
William J. Gane
John Grava

ZOOLOGY
Kitson A. Broadbelt
Nathan Fitelson
Milton Selig

1939-1940 CERTIFICATES AWARDED

BOTANY 1

Anthony Albrecht
Kitson A. Broadbelt
Marie M. Fortin
William J. Gane
Anne B. Gehring
John F. Hardecker
Dorothy Heritage
E. Frances Hervey
Daniel Hofheimer
John G. Hope
Carroll R. McDonnell
Agnes McFarland
Blanche Manning
Caroline Reed
Mary H. B. Schrack
George F. Stauffer
Lelia M. Stauffer
William Thompson
Robert W. Tuckey
Gertrude A. Vieweger
Agnes R. Zimmer

INORGANIC CHEMISTRY 3

Charles H. Angstadt
Robert L. Anthony
Edwin R. Cornish, Jr.
William J. Gane
J. Clement Jenkins
Myron Kreskovsky
Robert D. Lehman
Paul A. Lockrey
William R. Mitchell
Irving Nagelberg
William B. Reiff
Frank Rush
Samuel R. Schwarz
Samuel Shober
William Thompson
Raymond S. Whitehead

ORGANIC CHEMISTRY 3

William L. Cobb
Edwin R. Cornish, Jr.
William J. Gane
John Grava
Robert L. Johnston
Clarence Mosby
William B. Reiff
Edward A. Schuman
Samuel Shober
Theodore Sippi
Raymond S. Whitehead

ENGINEERING 1

George W. Baker
James Barrows
Lorenzo V. Blackston
John M. Bley
William H. Brown
Charles B. Davidson
Joseph Davidson
Robert Dunn
Joseph S. Ferringo
Paul A. Fisher
William Heck
Edward Herrera
Robert L. Johnston
Louis S. Langford
William M. Lubar
Ernest Metzner
Leslie Mitchell
L. Gilbert Obermiller
Raymond C. Patton
William A. Reese
George H. Shandle
Franklin H. Shank
Samuel Shober
Harry D. Smith
Charles I. Wilkinson
Norman T. Wineke

ZOOLOGY 4

Kitson A. Broadbelt
Elizabeth L. Clegg
Joseph M. Devlin
Anne B. Gehring
John F. Hardecker
Agnes McFarland
Cathryn E. Pratt
Sherman J. Pratt
Milton Selig
Samuel Shober
George Strohm
Gertrude Vieweger

GEOLOGY 1

Ina Bein
William L. Lichten
Albert H. Petri
Cathryn E. Pratt
Sherman J. Pratt
Albert Schwabeland
Samuel Shober
Clarence Strohm
Charles S. Thompson
William Thompson
Charles I. Wilkinson

PHYSICS 2

Charles H. Angstadt
Adolph W. Awot
Edwin R. Cornish, Jr.
Michael C. Gumrot
William D. Haenger
Edwin E. Hahn, Jr.
Benjamin J. Patton
Sherman J. Pratt
William A Reese
Samuel Shober

FACULTY

JOHN WAGNER, Jr.

B.S. in C.E. 1913, University of Pennsylvania.
C.E. 1920, University of Pennsylvania.
1913–1916, Draftsman, Phoenix Bridge Company.
1916–1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921–1926, Assistant Supervisor Track, Reading Company.
1926–1928, Supervisor Track, Reading Company.
1928–1936, Industrial Agent, Reading Company.
1936 to date, Assistant General Freight Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date.

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899–1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906–1915.
Head of Science Department, Germantown High School, 1915–1923.
Principal, Roxborough High School, 1923–1924.
Principal, Germantown High School, 1924 to date.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906–1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:

"Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
"Ether Waves and the Messages They Bring," Transactions of the Wagner Free Institute of Science.
"The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900–1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901–1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916–1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921–1937.
Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.
Dean of the Faculty.
Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Sc.D. (Hon.), Bucknell, 1934.
Director of Research, John B. Stetson Company, 1925 to date.
Research Adviser, McNeil Laboratories, Philadelphia, 1937 to date.
Director of Laboratories, Stetson Hospital, 1920 to date.

Editor, American Journal of Pharmacy, 1921 to date.
Professor of Pharmacy, Philadelphia College of Pharmacy and Science.
Dean of Pharmacy, Philadelphia College of Pharmacy and Science, 1938 to date.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Member American Chemical Society.
Member American Pharmaceutical Association.
Publications:
"Recent Remedies," 1926 (revised 1928). International Publications, N. Y.
"Popular Science Lectures" (Editor). Phila. College of Pharmacy and Science, Phila.
U. S. Dispensatory (Collab. Editor). Lippincott, Phila.
Formula Book, A. Ph. A. (Editor). Lippincott, Phila.
A Science Miscellany, International Printing Company, Phila.
Contributor to current chemical, pharmaceutical and medical literature.

GEORGE BRINGHURST KAISER

Educated in private schools.
Graduate, Franklin School.
After graduation spent several years in intensive botanical study and field work in northeastern United States.
Secretary of the Botanical Society of Pennsylvania for seven years and leader of its field trips.
Professor of Botany, Wagner Free Institute of Science, 1927 to date.
Curator, Moss Herbarium, Sullivant Moss Society.
Treasurer, Delaware Valley Naturalists' Union.
Member, Academy of Natural Sciences.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology and Stratigraphy in Princeton University.
Lecturer on Paleontology and Geology, University of Pennsylvania.
Acting Curator, Department of Paleontology, Academy of Natural Sciences of Philadelphia.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Secretary of the International Paleontological Union.
Editor of the section of General Paleozoology of *Biological Abstracts*.
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, Colorado School of Mines, as a consulting paleontologist and research associate.

REGULAR LECTURES, SESSION OF 1940–1941

BOTANY 2

PROFESSOR KAISER

Taxonomy

Lectures begin at 8 P. M.

1. Monday, September 9.
   Myxomycetes. Slime moulds. The borderland of plants and animals.

2. Monday, September 16.
   Cyanophyceae. Blue-green algae. Early organisms of simple structure upon the cooling earth-crust. Algae of hot springs and arctic regions.

3. Monday, September 23.
   Schizomycetes. Bacteria. Types and kinds. Important bacterial human and plant diseases. Plants that fix nitrogen.

4. Monday, September 30.
   Chlorophyceae. *Phycomycetes*. Green algae and algal fungi. Pond scum, desmids and diatoms. Moulds and mildews.

5. Monday, October 7.
   Phaeophyceae. *Rhodophyceae*. Brown and red seaweeds. Color in relation to light supply. Economic uses.

6. Monday, October 14.
   Ascomycetes. Sac fungi. Truffle, Morel and Peziza. Ferment organisms: saccharomycetes. Moulds.

7. Monday, October 21.
   Lichenes. Lichens. Soil building and reproduction. Curious uses. Litmus, rock tripe, reindeer moss.

8. Monday, October 28.
   Basidiomycetes. Smuts of corn, wheat, oats, and onion. Rust of wheat, white pine blister rust and cedar apple.

9. Monday, November 4.
   Basidiomycetes (Continued). Gilled fungi; edible and poisonous forms. Death Angel and Fly Agaria. Coral and bracket fungi. Puff balls and stink-horns. Phosphorescent species.

10. Monday, November 11.
    Hepaticae. Liverworts. Green plants that have acquired a land habit. Development of stomata.

11. Monday, November 18.
    Musci. True mosses. Green spore-bearing plants. Soil-formers. Peat mosses. Andreaea. The order Bryales.

12. Monday, November 25.
    Filices. True ferns. Adder's tongue and moonwort. The Polypody family. Lime-loving species. Wall-rue, cliff brake and walking fern.

13. Monday, December 2.
    Other Pteridophyta. Fern allies. Water ferns, salvinia, horsetails, club mosses and their kin. Fossils of the coal measures. Pteridosperms.

14. Monday, December 9.

Gymnosperms. Cycads and ginkgo, sole surviving representative of a once important family. The long-lived yew. Pines and other conifers. Gnetaceae and the remarkable Welwitschia of the African desert.

Field Trip

The class in Botany will be conducted on a field trip under the leadership of Professor Kaiser. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

INORGANIC CHEMISTRY 4

Professor Horn

Chemistry of the Metals

Lectures begin at 7.45 P. M.*

1. Tuesday, September 10.

Iron. Metallurgy: ore, mineral, gangue, flux, slag. Cast iron, white and gray. Wrought iron. Steels: open hearth, Bessemer, crucible. Tempering. Case-hardening.

2. Tuesday, September 17.

Iron (Continued). Chemical properties of iron. Ferrous and ferric compounds. Analytical recognition. Photochemical properties. Blue printing. Biologic importance. Ink.

3. Tuesday, September 24.

Copper. Principal ores. Native copper. Refining. Alloys. Chemical properties. Analytical recognition. Biologic occurrence. Electric cell.

4. Tuesday, October 1.

Lead. Principal ores. Parke's process. Pattisonizing. Cupellation. Fire assay. Atomic weights of lead. Alloys. Chemical properties. Analytical recognition. Biologic effects. Storage batteries.

5. Tuesday, October 8.

Mercury. Principal ores. Preparation. Refining. Amalgams. Chemical properties. Analytical recognition. Mercurous and mercuric compounds. Biologic effects. Fulminating mercury.

6. Tuesday, October 15.

Gold and Platinum. Occurrence. Placer deposits. Free-milling ores. Cyanide process. Toning. Gold leaf. Alloys of gold; of platinum. Chemical properties. Platinum sponge. Platinum black. Catalysis.

7. Tuesday, October 22.

Silver. Sources. Cupellation and parting. Plating. Alloys. Cleaning silver. Chemical properties. Analytical recognition. Biologic effects. Lunar caustic, colloidal silver, silver nitrate, indelible ink. Photosensitiveness. Daguerreotypes. Wet plates. Dry plates and films.

8. Tuesday, October 29.

Cobalt and Nickel. Sources. Carbonyls. Mond process. Electro-deposition. Alloys. Monel metal. Chemical properties. Edison storage battery. Metal-ammines. Principal and secondary valence. Werner's hypothesis.

9. Tuesday, November 5.

Cadmium and Tin. Sources. Metallurgy. Liquation. Alloys. Fusible metals. Chemical properties. Analytical recognition. Mordants. Tin salt. Tin plate and terne plate. Corrosion of metals. Recovery of tin.

* Please note the hour.

10. Tuesday, November 12.

    Tungsten and Titanium. Sources. Chemical properties. Tungsten steel. Titaniferous iron ores. Tungsten filaments. Other uses.

11. Tuesday, November 19.

    Metallography. The phase rule. Eutectics. Thermal analysis. Determination of formulas of compounds neither isolated nor analyzed. Solid geometry of chemistry.

12. Tuesday, November 26.

    Bismuth and Molybdenum. Sources. Alloys. Chemical properties. Analytical recognition. Basic salts. Phosphomolybdates, and arsenomolybdates. Complex inorganic acids. Molybdenum steel.

13. Tuesday, December 3.

    Uranium and Rarer Metals. Sources. Chemical properties. Uranyl compounds. Transformation of elements. Emanations. Transmutation of metals. Modern alchemy.

14. Tuesday, December 10.

    Metallic Poisons. Industrial poisons. Germicides. Insecticides. Everyday hazards due to toxicity of metals.

ORGANIC CHEMISTRY 4

PROFESSOR GRIFFITH

Compounds of Nitrogen

Lectures begin at 8 P. M.

1. Wednesday, September 11.

   Nitrogen Itself. Inert alone but restless in company. An essential ingredient of all living tissue. Proteins. Classification. Identification. General characteristics.

2. Wednesday, September 18.

   Proteins. Their rôle in animal diet. Protein foods. Calorific value. Important proteins—Amino-acids, gluten, gelatin, casein, etc.

3. Wednesday, September 25.

   Protein Derivatives. The body's way of simplifying the complex proteins by its schemes of digestion. Pepsin, trypsin, etc. Derivatives of proteins, amino-acids, proteoses, peptones. The cinders of protein digestion—urea, creatinin, etc.

4. Wednesday, October 2.

   The Cycle of Nitrogen in Nature. Changing simple inorganic nitrogen compounds to complex organic bodies—and reverse. The nitrate beds of Chile. Soil and soil nutrition.

5. Wednesday, October 9.

   Man's Conquest of the Air. Not with wings, but with brains. Nitrogen fixation. Nitrogen—inactive—inert and useless—chained and put to work. The Haber process. Other fixation processes.

6. Wednesday, October 16.

   Nitrogen at War. The nitrogen containing explosives—nitroglycerine, dynamite, lyddite, etc. Nitrogen dye-stuffs—picric acid, etc.

7. Wednesday, October 23.

   Nitrogen at Peace. Textiles (casein, zein, soya and other fibers). Plastics (cellophane and nitrated cotton compounds).

8. Wednesday, October 30.

   Miscellaneous Nitrogen Compounds. Vitamins and hormones. Regulators of living processes. Purines, amines, amides, urea, caffein, theobromine and other odds and ends of nitrogen compounds.

9. Wednesday, November 6.

   Miscellaneous Nitrogen Compounds (Continued). The cyanogen compounds. Plants that are poison factories. The bitter almond, wild cherry, peach, and hydrogen cyanide. Cyanamide.

10. Wednesday, November 13.

    Alkaloids. General characteristics. Origin—their rôle in plant life. Group reactions. Adsorption phenomena. Color reactions.

11. Wednesday, November 20.

    Alkaloids (Continued). The Pyridine and Tropine group—Coniine—the Socratic poison. Nicotine—the democratic poison. Atropine—the mydriatic poison. Cocaine—the anaesthetic poison.

12. Wednesday, November 27.

    Alkaloids (Continued). The Quinoline and Isoquinoline groups. Quinine bark of Peru, made famous by Jesuit fathers. Strychnine, the toxic and tonic alkaloid. Morphine, codeine, hydrastine, etc.

13. Wednesday, December 4.

    Alkaloids (Continued). Artificial and miscellaneous alkaloids. Apomorphine, homatropine, heroine, emetine from ipecac, and sanguinarine from blood root.

14. Wednesday, December 11.

    Ptomaines and Allied Compounds. Ptomaines—toxins and toxalbumins. Facts and fallacies of food poisoning.

ENGINEERING 2

PROFESSOR WAGNER

Civil Engineering Structures

Lectures begin at 7.45 P. M.*

1. Friday, September 13.

   Foundations on Land. Designing the footing. Preparation of the bed.

2. Friday, September 20.

   Foundations on Land and Water. Foundations on piles. Cofferdams.

3. Friday, September 27.

   Foundations in Water. Open caisson process. Dredging through wells. Pneumatic caissons.

4. Friday, October 4.

   Masonry Construction. Stone masonry. Concrete. Brick masonry. Retaining walls, piers, etc.

5. Friday, October 11.

   Framing in Wood and Steel. Wood framing. Iron and steel framing. Joints. Rivets. Pins.

6. Friday, October 18.

   Bridges. Definitions. Classification. History. Beam bridges.

7. Friday, October 25.

   Bridges (Continued). Plate girders.

* Please note the hour.

8. Friday, November 1.

   Bridges (Continued). Trusses. Classification. Design of tension and compression members.

9. Friday, November 8.

   Bridges (Continued). Trusses (Concluded). Details and methods of erection. Cantilevers.

10. Friday, November 15.

    Bridges (Continued). Suspension. Tubular. Arches—(a) stone, (b) steel.

11. Friday, November 22.

    Bridges (Concluded). Movable bridges. Viaducts.

12. Friday, November 29.

    Roofs. Types of trusses. Special designs for train sheds.

13. Friday, December 6.

    Details of Construction. Rivets. Riveted work, pins, forging details. Bridge floors—(a) railroad, (b) highway.

14. Friday, December 13.

    Buildings. Design of buildings of wood, steel, reinforced concrete, general building construction.

ZOOLOGY 1

MR. LAWRENCE

Invertebrate Animals

Lectures begin at 8 P. M.

1. Monday, January 6.

   The Myriads of Small Animal Life of Land, Stream, and Sea (Protozoa). Their forms, life habits, and relations to other animals and to man.

2. Monday, January 13

   Animals That Look Like Plants (Porifera) Their structure, methods of reproduction, and different types of skeletal material. Their economic value.

3. Monday, January 20.

   Animals That Have the Beauty of Flowers (Coelenterata). Anemones, corals, jellyfish, hydroids, and others. Producers of islands and gem materials Alternation of generations.

4. Monday, January 27.

   A Great Group of Animals Restricted to the Sea (Echinodermata). Sea cucumbers, starfish, sea lilies, sea urchins, etc. A strange water vascular system for locomotion. Economic importance.

5. Monday, February 3.

   Worms of the Sea (Annelida, Platyhelminthes, and Nemathelminthes). Mud and sand dwellers. Tube makers. Although abundant, rarely seen.

6. Monday, February 10.

   Uninvited Guests of Man and Other Animals. The story of worm parasites. The tapeworm, porkworm, ascaris, flukes, guinea worm, etc.

7. Monday, February 17.

   Soft Animals with Hard Shells and Their Relatives without Shells (Mollusca). Pearl oysters, octopi, cuttlefish, squids, nautili, etc. Wide range of economic importance.

8. Monday, February 24.

   Jointed-legged Marine Animals without a Backbone (Crustacea). Lobsters, crabs, and their smaller cousins. Interesting life histories. Food for other animals and for man.

9. Monday, March 3.
   Man's Worst Enemies of Farm, Orchard, and Garden (Insects). Their many adaptations, food habits, and reproduction. How to cope with them.

10. Monday, March 10.
    Colonial Insects. Bees, wasps, ants, and termites. Organization of the colony. Their homes and their activities.

11. Monday, March 17.
    Insects as Transmitters of Diseases. Flies, mosquitoes, lice, bedbugs, and fleas. What we know about their activities and how we meet the problems.

12. Monday, March 24.
    Insects as Benefactors of Man. Pollinators, predators, and scavengers. Producers of honey, wax, silk, lac, medicine, food, etc.

13. Monday, March 31.
    Mites, Ticks, Harvestmen, Scorpions, and King Crabs. How they cause some diseases and transmit others. Their interesting instincts and activities.

14. Monday, April 7.
    Spiders. Their homes and habits. Love, courtship, and murder. Their war on insects.

Field Trip

The class in Zoology will be conducted on a field trip under the leadership of Mr. Lawrence. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

GEOLOGY 2

Professor Howell

Physical Geology

Lectures begin at 7.45 P. M.*

1. Tuesday, January 7.
   The Old Earth's Weather-beaten Face. Why it is so seamed and furrowed.

2. Tuesday, January 14.
   What Lies Beneath the Earth's Stony Skin. The hot rocks within the Earth and the forces which cause them to move.

3. Tuesday, January 21.
   What Happens When the Earth's Internal Forces Grow too Powerful. The catastrophic results of the readjustments which then take place.

4. Tuesday, January 28.
   What Becomes of Volcanoes and Mountain Ranges as they Grow Old. Why the "everlasting hills" are not really everlasting.

5. Tuesday, February 4.
   Rivers and their Freight. How rivers carry mountains down to the sea.

6. Tuesday, February 11.
   Glaciers: Frozen Rivers. How they plow their way across the land and into the oceans.

7. Tuesday, February 18
   Waters Which Flow Underground. The sheet of water which feeds our springs and wells.

* Please note the hour.

8. Tuesday, February 25.

   Petroleum, Which has Revolutionized our Civilization. How it is formed and how we find and secure it.

9. Tuesday, March 4.

   Coal, the Rock Which Once was Plants. How nature baled and buried whole forests long ago.

10. Tuesday, March 11.

    The Skirts of the Continents, Washed by the Sea. How they carpet the shallow sea bottoms.

11. Tuesday, March 18.

    The Uneasy Edges of the Continents. The lines of weakness which encircle the continental cores.

12. Tuesday, March 25

    How the Skirts of the Continents get Rumpled and Crumpled. How mountain ranges are born in the sea.

13. Tuesday, April 1.

    The Treasures Locked in the Hearts of the Mountains. The ores which make modern civilization possible.

14. Tuesday, April 8.

    How Men Unlock the Treasures of the Rocks. How geologists search for and find the ores in the Earth's crust.

Field Trip

The class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

PHYSICS 3

Professor Seely

Light

Lectures begin at 8 P. M.

1. Wednesday, January 8.

   Historical Development of Our Knowledge of Light. Early knowledge among the Greeks and Arabs. Light in the Dark Ages. The Renaissance. The Corpuscular Theory. Galileo and Newton. Electro-magnetic Wave Theory. Huygens, Maxwell and Count Rumford.

2. Wednesday, January 15.

   Propagation of Light. How light travels from its source and how its intensity varies as it travels. Shadows and their peculiarities in eclipses.

3. Wednesday, January 22.

   Propagation (Continued). Brightness of light and its illumination of objects. Measuring light and illumination. The speed at which light travels.

4. Wednesday, January 29.

   Interference and Polarization. The nature of a beam of light. Description of interference phenomena. Polarized light and its uses.

5. Wednesday, February 5.
   Reflection of Light. How light is thrown back from a surface. Diffusing surfaces and mirrors. How images are formed by light from plane mirrors.

   Wednesday, February 12. No lecture.

6. Wednesday, February 19.
   Reflection (Continued). How real and apparent images are formed by concave and convex mirrors.

7. Wednesday, February 26.
   Refraction of Light. How light is bent as it passes from one medium into another having a different density. Lenses and prisms. How images are formed by lenses.

8. Wednesday, March 5.
   Dispersion of Light. How a beam of white light may be separated into its colors. Complementary colors. Pigments.

9. Wednesday, March 12
   Coloration by partial absorbtion and reflection of white or colored light. Opalescence, phosphorescence and fluorescence.

10. Wednesday, March 19.
    Spectra. The spectrum or color band made by sun's light. Fraunhofer's lines. Bright-line and dark-line spectra. Some uses of the spectroscope.

11. Wednesday. March 26.
    Spectra (Continued). Invisible light beyond the red and violet ends of the spectrum. Composition of sun's light compared with that of artificial lights.

12. Wednesday, April 2.
    Optical Instruments. A study of the magnifying glass, the compound microscope, and the telescope.

13. Wednesday, April 9.
    Optical Instruments (Continued). The projection lantern and camera and the moving picture machine. The stereoscope and binocular vision.

14. Wednesday, April 16.
    Photography. The photographic process. How the image is fixed. Lens correction. Color photography.

MUSEUM TALKS

Monday evenings at 7 o'clock

This series comprises informal talks, given on Monday evenings in the Museum, illustrated by specimens.

PROFESSOR HOWELL

Minerals, Rocks and Fossils

Sept. 9.	Minerals, The Natural Chemical Compounds of Which Rocks are Made.
Sept. 16.	Igneous, Sedimentary, and Metamorphic Rocks, of Which the Earth is Made.
Sept. 23.	Fossils. What They are and What They Tell us of the Past.
Sept. 30.	Plant Fossils. Stony Seaweeds, Coal, Amber, Petrified Logs and Flowers.
Oct. 7.	Animal Fossils. Sponges, Corals, Shell-fish, Crustaceans, Vertebrates.
Oct. 14.	Human Fossils. Bones, Artifacts, Carvings, Cave Paintings.

Mr. Lawrence

Animal Life Regions of North, South and Central America

Oct. 21. Animals and Man in the Far North. The Why and How of Their Existence There.

Oct. 28. Animals of the Mountains from Patagonia to Alaska. Eastern Mountain Life.

Nov. 4. Animal Life in the Woods and Waters of the Two Great River Valleys of North and South America, the Amazon and the Mississippi.

Nov. 11. Central America, the Meeting Place of Northern and Southern Fauna. Jungle Life.

Nov. 18. Animals of Plains, Prairies and Pampas.

Nov. 25. Coastal Lowland Life Zones North and South. Life in Bayous and Swamps.

Mr. Hope

Eurasia and Africa: Their Biologic Story

Dec. 2. Life in the Frozen Desert of the Far North-Tundra.

Dec. 9. Plant and Animal Life in the Grassy Steppes of Asia and the African Veldt.

Dec. 16. Forest Life: Asiatic Taiga, European Forests and Mediterranean Scrub.

Dec. 23. No Lecture.

Dec. 30. No Lecture.

Jan. 6. The Natural History of Alpine Peaks, English Fells and African Mountains of the Moon. The Roof of the World in Himalaya.

Jan. 13. Deserts and the "Abundant Life." The Sahara, Kalahari Pans and the Mongolian Desert.

Jan. 20. Luxuriant Life of Tropical Jungles: Africa, the Orient and the Malay Archipelago.

Miss Borden

Life in the Australian Region

Jan. 27. The Island Continent—In Ancient Times and Now.

Feb. 3. Life On and About the Great Barrier Reef.

Feb. 10. Forests and Forest Life of Australia, Tasmania and New Zealand.

Feb. 17. Birds of the Australian Region

Feb. 24. Living Remnants of an Ancient Fauna.

Mar. 3. Flora and Fauna of the Australian Region as Influenced by Man.

Professor Kaiser

Great Groups of Plants

Mar. 10. Elm, Hackberry, Mulberry, Fig, Hemp, Bread Fruit.

Mar. 17. Sandalwood, Mistletoe, Dutchman's Pipe.

Mar. 24. Sweet Shrub, Custard Apple, Nutmeg, Laurel.

Mar. 31. Manioc, India Rubber Plant, Sand Box, Croton, Starwort.

Apr. 7. Tea, St. John's-wort, Rock Rose, Violet, Passion Flower.

Apr. 14. Loosestrife, Evening Primrose, Fuchsia, Clove, Allspice, Pomegranate.

GENERAL SCHEDULE OF REGULAR LECTURES

Subjects of courses in each of the four successive years constituting a full term.

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles, Notation, Nomenclature.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

ZOOLOGY

1. Invertebrate Animals.
2. Vertebrate Animals.
3. Human Biology.
4. Principles of Animal Life.

BOTANY

1. Morphology.
2. Taxonomy.
3. Taxonomy (continued).
4. Physiology and Ecology.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

LECTURES UNDER RICHARD B. WESTBROOK FOUNDATION

1912.—Ancient Civilization of Babylonia and Assyria. *Morris Jastrow, Jr., Ph.D.*
1913.—Conservation of Natural Resources.
Gifford Pinchot, Marshall O. Leighton, Overton W. Price, Joseph A. Holmes.
1914.—The Theory of Evolution. *William Berryman Scott, Ph.D., LL.D.*
1915.—Invisible Light. *Robert Williams Wood, LL.D.*
1916.—Aspects of Modern Astronomy. *John Anthony Miller, A.B., A.M., Ph.D.*
1917.—Heredity and Evolution in the Simplest Organisms.
H. S. Jennings, B.S., A.M., Ph.D., LL.D.
1918.—The Chemistry, Nutritive Value and Economy of Foods.
Harvey W. Wiley, A.M., M.D., B.S., Ph.D., LL.D., D.Sc.
1919.—The Origin and Antiquity of the American Indian.
Aleš Hrdlička, M.D., Sc.D.
1920.—Chemistry and Civilization. *Allerton S. Cushman, B.S., A.M., Ph.D.*
1921.—Microbiology. *Joseph McFarland, M.D., Sc.D.*
1922.—Evolution of the Human Face. *William K. Gregory, Ph.D.*
1923.—The Philosophy of Sanitation. *George C. Whipple, B.S.*
1924.—The Distribution of American Indian Traits. *Clark Wissler, A.M., Ph.D.*
1925.—Structural Colors. *Wilder D. Bancroft, Ph.D., Sc.D.*
1926.—The Animal Mind; its sources and evolution. *George Howard Parker, Sc.D.*
1927.—An Interpretation of Atlantic Coast Scenery. *Douglas W. Johnson, Ph.D.*
1928.—The Science of Musical Sounds. *Dayton C. Miller, Ph.D.*
1929.—Volcanoes and Vulcanism. *William B. Scott, Ph.D., LL.D.*
1930.—Present Problems of Evolution. *Edwin Grant Conklin, Ph.D., ScD., LL.D.*
1931.—The Problems of the Origin and Antiquity of the American Aborigines in the Light of Recent Explorations. *Aleš Hrdlička, M.D., Sc.D.*
1932.—Common Sense, Science and Philosophy. *John Dewey, Ph.D., LL.D.*
1933.—Social Relations in Monkey, Ape and Man.
Robert M. Yerkes, A.M., Ph.D., Sc.D.
1934.—Chemistry and Industrial Progress as exemplified in the Study of Hydrogen and Oxygen. *Hugh S. Taylor, D.Sc., F.R.S.*
1935.—Recent Progress in Astronomy. *Samuel A. Mitchell, M.A., Ph.D., LL.D.*
1936.—Real Lilliputians of the Universe. *Ellis L. Manning.*
1937.—Biology and Social Problems. *Edwin Grant Conklin, Ph.D., Sc.D., LL.D.*
1938.—Emotions and the Social Order. *Frederick H. Lund, A.M., Ph.D.*
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BULLETIN

of the

WAGNER FREE INSTITUTE OF SCIENCE

PUBLISHED BY THE INSTITUTE

SYDNEY L. WRIGHT, *Editor*

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A NEW SILURIAN SPONGE FROM TENNESSEE

By B. F. HOWELL

The spherical, or subspherical, fossil sponges, which are usually called *Hindia fibrosa* or *Hindia sphaeroidalis*, are common objects in the rocks of a number of North American Silurian and Lower Devonian formations. Four other species that have been referred to the genus *Hindia*—*H. gregaria*, *H. inaequalis*, *H. parva*, and *H. subrotunda*—are also found, although less abundantly, in some of the Lower Paleozoic formations of North America; and sponges of this sort must have lived in many places on the floors of the seas that flooded this continent in Ordovician, Silurian, and Early Devonian times.

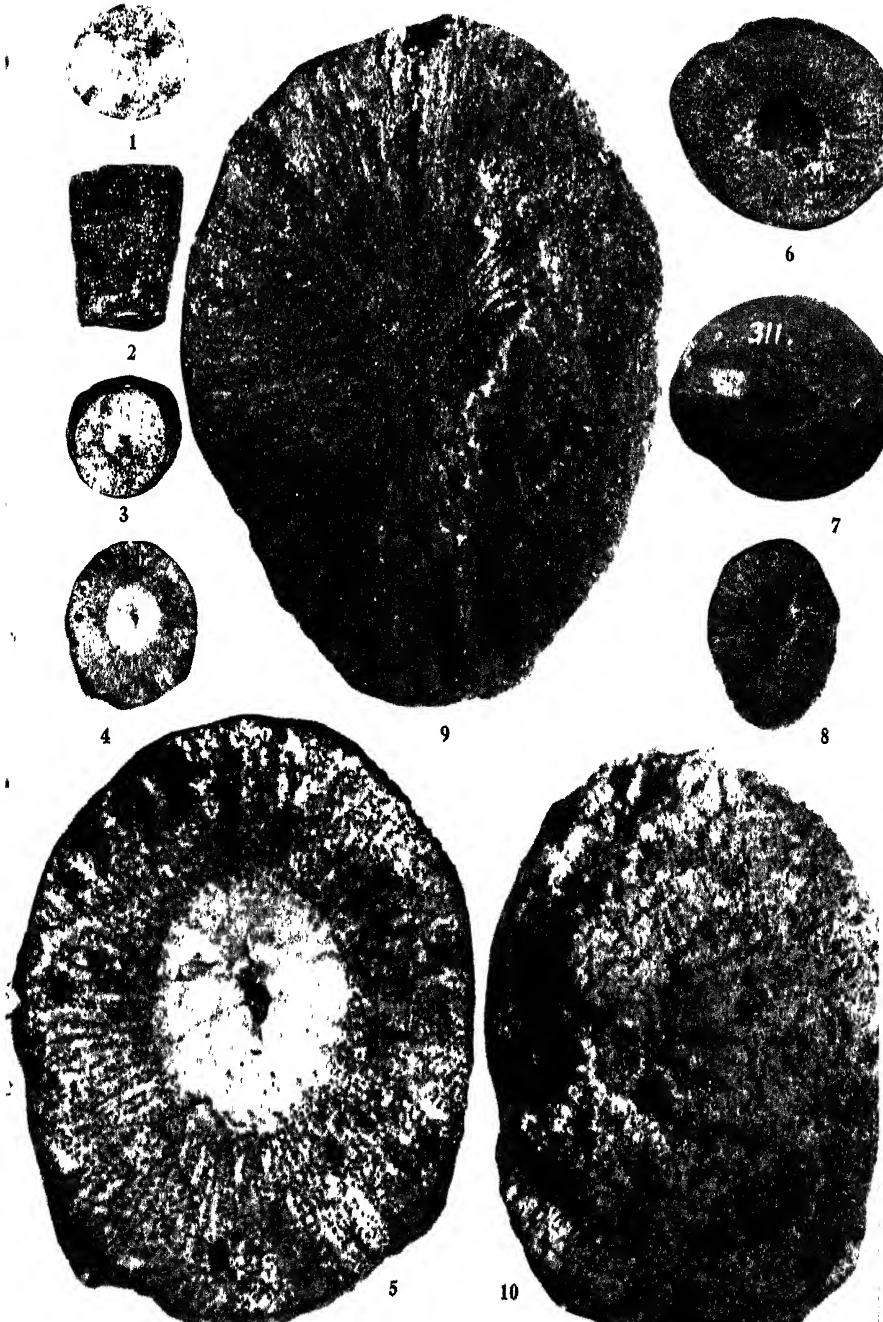
Although some individual species of sponges, unlike species of other kinds of animals, have no set form of body by which they can be recognized, but reveal their identity only in the shape of their spicules, the five forms mentioned above (all the species of this sort of sponges that have been known up to this time in North America) have resembled each other in form in that their bodies were all either approximately spherical or hemispherical in shape. The discovery of what would appear to be a new species, whose internal structure seems to have been of the sort typical of *Hindia*, but whose body was in no way spherical, but was rather cylindrical in form, is therefore of more than ordinary interest to students of fossil sponges.

Only two specimens of this new species are known to the writer. They were collected from Middle Silurian rocks near Clifton, Wayne County, Tennessee. A specimen of one of the spherical species of the genus, *sphaeroidalis*, seems to have been collected from the same place, as it bears the same locality label as the cylindrical specimens and is in the same state of preservation. This specimen, which is no. 511 in the Paleontological Museum of Princeton University, is illustrated here (see figs. 6 and 7) for comparison with the cylindrical specimens. As both examples of the new sponge are incomplete, they leave us in some doubt about the shape of the entire body of the species to which they belong; but the form of the more complete specimen of the two seems to indicate that the whole body was shaped like a cylinder which tapered toward one end—presumably the lower end—of the animal.

Explanation of Figures

1. *Hindia cylindrica*, new species. The holotype, top view. × 1. Princeton University no. 49921.
2. The same specimen, side view. × 1.
3. The same specimen, bottom view. × 1.
4. *Hindia cylindrica*, new species. The paratype, top view. × 1. Princeton University no. 49922.
5. A part of the same specimen, enlarged. × 4.
6. *Hindia sphaeroidalis* Duncan. Perpendicular section. × 1. Princeton University no. 311.
7. The same specimen, exterior view, from the side. × 1.
8. *Hindia sphaeroidalis* Duncan. Cross section, naturally etched. × 1. Princeton University no. 45182.
9. A part of the same specimen, enlarged. × 4.
10. *Hindia sphaeroidalis* Duncan. Part of an artificially etched specimen, enlarged. × 4. Princeton University no. 5929.

The specimens illustrated in figures 8 to 10 are from the Lower Devonian New Scotland Formation of New York.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Unfortunately the preservation of the internal structure of these cylindrical specimens is not as good as might be desired. The fossils are silicified and the details of structure are somewhat indefinite, although the general arrangement of parts is clearly shown. Fossils of *sphaeroidalis*, the commonest species of the genus and the one with which our specimens have consequently been compared, usually lack their spicules and have their internal structure shown by siliceous fillings of the canals. This appears to have been the case with our specimens also, but the canal fillings are not so beautifully preserved in them as they often are in examples of *sphaeroidalis.* Nevertheless the evidence would seem to justify the assignment of our new species to the same genus as that to which *sphaeroidalis* belongs. At least, such an assignment seems to be desirable until better examples of our form are discovered to confirm it or indicate a different generic reference.

As to what name should be applied to the genus involved, there has been some difference of opinion among the authors who have dealt with this group of sponges. In the year 1878 the name *Microspongia* was proposed by Miller and Dyer* as a generic name for a new species of sponge, then called *Microspongia gregaria*, found in Upper Ordovician rocks near Cincinnati, Ohio. A year later another name, *Hindia*, was published by Martin Duncan† for a genus designed to contain the then new species, *sphaeroidalis*. At that time it was not known that these two species were so similar as to be probably referable to a single genus, and this fact was apparently not pointed out in print until 1915, when Dr. R. S. Bassler called attention to it.‡ Dr. Bassler, then, while stating that the name *Microspongia* had been proposed before the name *Hindia* and that the two names both applied to a single genus, accepted *Hindia*, and rejected *Microspongia.* He was probably influenced to make this choice because *Hindia* had for years been in common use for the species *sphaeroidalis*, which, because of its abundance and wide distribution, had been frequently referred to in the literature. For, until Dr. Bassler called attention to the fact that, although the very brief characterization and not very good illustrations of *Microspongia gregaria* published by Miller and Dyer did not show it, the type specimens of that species indicated that *Microspongia* and *Hindia* were congeneric, most other authors who had had occasion to refer to these sponges had assumed that the two genera were both valid and distinct. Dr. Bassler's decision to use *Hindia* rather than *Microspongia* was, however, contrary to the International Rules of Zoological Nomenclature, if the two names do really apply to a single genus; and he now considers§ that *Microspongia* is the proper name to adopt. With this decision the writer is in agreement, and the new species is therefore described as follows, and classed in a new family, the Microspongidae, as noted below.

* Miller, S. A., and C. B. Dyer. Journal of the Cincinnati Society of Natural History, vol. 1 (1878), p. 37.

† Duncan, Martin. Annals and Magazine of Natural History, 5th series, vol. 4 (1879), p. 91.

‡ Bassler, R. S. Bibliographic Index of American Ordovician and Silurian Fossils, U. S. National Museum Bulletin 92 (1915), p. 618.

§ Personal communication.

The writer has been unable to examine the type specimens of *Microspongia gregaria* as he has been unable to find where they are preserved.

CLASS: *Silicispongiae*
SUBCLASS: *Tetraxonida*
ORDER: *Lithistida*
SUBORDER: *Eutaxicladina*
FAMILY: *Microspongidae*, new family
Microspongia cylindrica, new species
(Figs. 1–5)

Body form tapering cylindrical; length unknown. Diameter of cylindrical body cavity one-third of that of whole sponge. Canals radiating horizontally from body cavity in radial arrangement, and apparently of same general shape and diameter as those of *Microspongia sphaeroidalis*.

The holotype is no. 49921 in the Paleontological Museum of Princeton University. The single known paratype is no. 49922 in the same museum.

Both specimens came from a Middle Silurian (Niagaran) formation of the Brownsport Group—probably the Beech River Formation—at Clifton, Wayne County, Tennessee.

In 1894 Hermann Rauff* proposed the family Hindiadae to contain the genus *Hindia*. As the name *Hindia* is no longer to be used, this family name must be abandoned. The new name, Microspongidae, is proposed in its place, as noted above. *Microspongia* then becomes the type genus of that family, with *Microspongia gregaria* Miller and Dyer as its genotype. The writer knows of no other genus which is referable to the family.

Microspongia cylindrica somewhat resembles in form *Astylospongia imbricato-articulata* (Roemer), a sponge occurring also in the Middle Silurian rocks of Tennessee; but its internal structure is different, the central cavity of *M. cylindrica* being sharply defined and the spicules being of a different shape, while its outer surface is smooth and even, not nodose, as it is in *A. imbricato-articulata*.

* Rauff, Hermann. Palaeontographica, vol. 40 (1894), p. 327.

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A NEW SPONGE FROM THE ORDOVICIAN OF NEVADA

By B. F. HOWELL, A.M., PH.D.

Sponges of the genus *Zittelella* have long been known to be members of the fossil marine faunas of the Lower Ordovician Black River and Chazy formations of eastern and central North America.* They appear, however, not to have been reported from any Early Ordovician strata of the western part of the continent. Therefore the discovery, in the Upper Canadian or Chazyan Tank Hill Limestone of Nevada, of two fossils which appear to be referable to a new species of this genus, is worthy of record.

Zittelella clarae, new species

The specimens on which this species is based are preserved in a single block of gray limestone whose other fossils indicate that the two sponges were buried in the more or less upright position in which they doubtless grew when alive. Both specimens pass completely through the block, so that each exhibits two transverse sections. A part of the outer wall of one specimen is also exposed on one side of the block. Both the internal structure and the external form and surface details are therefore shown as clearly as the method of preservation allows. As the fossils are recrystallized the details are unfortunately only imperfectly preserved. This has prevented the determination of the form of the spicules and the exact courses of the canals and makes impossible an absolutely certain identification of the genus.

The parts of the two specimens which are preserved are pieces of two slightly tapering cylindrical bodies, each about 5 centimeters in diameter and 5 centimeters long. There appears to have been a cylindrical cavity, 1½ centimeters in diameter, in the center of each sponge. From this cavity many small canals radiated horizontally outward to the outer surface of the sponge,

* R. S. Bassler: Bibliographic Index of American Ordovician and Silurian Fossils. United States National Museum Bulletin 92 (1915), pp. 1337–1338. Also B. F. Howell: The sponge, "*Zittelella varians*," from the Ordovician of Vermont. Bulletin of the Wagner Free Institute of Science, vol. 13 (1938), pp. 31–34, 1 pl.

EXPLANATION OF PLATE

Zittelella clarae, new species × 1. Holotype (a) and paratype (b). Part of the net-like outer wall of the holotype can be seen to the right of the letter "a." From the lower part of the upper member of the Tank Hill Formation on the northwestern shoulder of Skalecky Mountain, Ely Springs Range, Nevada.

where their external apertures seem to have formed the pores in the net-like wall of the animal. These canals and pores are approximately ¾ mm. in diameter and are separated by walls about ½ mm. thick.

It is not possible to determine from our specimens how long the entire sponges were or what was the nature of either extremity.

The general appearance of the cross sections of these sponges and of the outer surface is that characteristic of other species of *Zittelella*. But the central cavity is not so characteristic of that genus. The other species of *Zittelella* which have been described have had only a shallow cavity in the center of the upper part of the body, while our species must have had a deep body cavity—how deep we do not know. It is possible that the method of preservation of our fossils has made this cavity seem more truly an open cavity than it actually was. If it was really as well developed as it seems to have been our species may not be a true *Zittelella*, and may require the erection of a new genus for its reception. It does not appear to be referable to any other genus of Early Paleozoic sponge, differing from *Calathium*, which it resembles in some respects, in having a much thicker body wall. The erection of a new genus to receive it is, however, not justified on the evidence of our two specimens alone.

Our specimens were collected by the writer's son, B. F. Howell, Jr., from the lower part of the upper member of the Tank Hill Formation on the northwestern shoulder of Skalecky Mountain, in the Ely Springs Range, in southeastern Nevada. They are nos. 53430a and 53430b in the paleontological collection of Princeton University. The specimen showing the outer surface (53430a) has been chosen as the holotype. The other (53430b) thus becomes a paratype.

The age of the beds from which these fossils were secured is probably Chazyan, although the lower beds of the Tank Hill Formation may be Canadian. The problem of the age of the Tank Hill was discussed by Dr. Edwin Kirk some years ago,* but the age of the formation is still somewhat doubtful.

* Kirk, Edwin. The Lower Ordovician El Paso Limestone of Texas and its Correlatives. American Journal of Science, 5th series, vol. 28, 1934, pp. 443–462 (discussion on pp. 454–455).

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A SYNOPSIS OF THREE LECTURES ON GEOGRAPHY AND ITS INFLUENCE ON HISTORY

(Delivered under the Richard B. Westbrook Free Lectureship, 1941)

By DERWENT WHITTLESEY, PH.D.
Associate Professor of Geography, Harvard University

LECTURE I

AN INQUIRY INTO THE RELATION BETWEEN GEOGRAPHY AND HISTORY

Unlike most natural sciences and some social sciences, geography and history belong to us all. The place we live in is an everyday familiar, and the life lived by us and our neighbors will one day be a part of history. If we stop to think of it, we realize that our lives are affected by the kind of place (environment) we live in and by the historical past that has modified that natural habitat to some extent.

It is reasonable to suppose that this has always been true. Nature must have played a prominent part in the unfolding of human affairs throughout the life of mankind, and man must have ceaselessly tried to use and modify nature to suit his own ends.

Environmental Determinism

It does not follow that geography has controlled the course of history. That can be proved an untenable hypothesis. On the contrary, man is the active agent in shaping the course of events. In doing so he utilizes nature's gifts so far as his wisdom and ingenuity permit. In restricted areas he can modify the appearance of the landscape by tracing new patterns upon it: fields and orchards for natural grasses or forests; factory sites on reclaimed tidal flats; lakelike reservoirs for stream valleys. In these cases the alteration is considerable, but the changes are rigidly confied within limits laid down by nature and the imprint is only skin deep.

As a rule, man makes no such pronounced alteration in natural features. Rather, human agency is the active element in an age-old collaboration between man and nature. The degree of man's conformance to environing conditions varies from place to place, and in any one place from time to time.

Where nature is harsh, it permits human society little choice of action.

There the pressure of the environment may amount to something approaching control. Where nature is more propitious, man may exert more or less choice as to how he shall utilize his habitat. In such favorable environments the limits to man's action are set farther apart. Nevertheless, they remain limits, and may not be transgressed with impunity. Wherever and whenever restrictions imposed by nature approximate control, little history is recorded. Conversely the most complex historical development occurs where natural environment is most benevolent and gives mankind maximum freedom of action.

The Four Great Historical Areas

Four large segments of the earth have had long, varied, and absorbing history and pre-history: Europe (including all the Mediterranean coastlands); South Asia; East Asia; Tropical Highland America and Eastern North America. All these areas lie mainly or wholly within the Northern Hemisphere. All are large and have vast expanses of fertile soil. All but a part of one are lowlands. All but one and part of another have a humid, middle-latitude climate. The exceptions mentioned are more apparent than real.

Some other parts of the earth have environments almost identical with these four, but have not been seats of important history. Most of them lie south of the Equator. They are small, separated from each other by large bodies of ocean, and they had no native endowment of plants and animals suited to domestication.

Progress has not been uniform over any of the four areas called history-makers, nor have any two of them advanced at the same rate. The earliest peoples who have left clear historical records, either written or archeologic, were denizens of dry habitats. Arid nooks, protected by surrounding uninhabitable wastes, permitted early growth. From each such alcove, the discipline of a somewhat advanced society reached out to cope with the more complex and refractory natural environment of nearby humid plains. In the Americas, however, the humid lowlands did not become historically significant until Europeans came in from overseas. This failure of the rule affords further evidence of the delicate balance between environing conditions and the timing necessary to achieve success.

Clearly, in these major historical areas geography has not controlled history. At the same time the course of history has been affected continuously by conditions of the natural environment in each of them.

If we must reject the doctrine of environmental control, we may set up instead a working hypothesis: *viz.*, the natural environment constitutes a frame of conditions within which mankind's manifold activities function.

Geography, Technology, and History

Whatever the problems set up by nature in constituting this frame, man seeks to solve them by his ingenuity. With the passage of time any group of people contrives a set of tools and instruments, and a body of intellectual concepts, fairly effective in coping with its natural environment. These material and non-material devices may be called the technologic equipment of the group. The items of the material technology (tools, implements, and

weapons) are necessary to human progress, but no more so than are intellectual devices, such as social taboos and modes of government.

The stage of technology of any human society is roughly determined by the time that has been available for perfecting it, coupled with the material base afforded by the habitat. The earth provides the basis for technologic progress.

The most obvious earth source of technology is the block of natural resources available. Minerals provide the raw material of tools and weapons. Native animal life furnishes food and stock for domestication. Natural vegetation feeds animals, yields some human food, and is the progenitor of agricultural and horticultural crops. Water, both superficial and underground, is a primary element of human existence, and has been subjected to increasing use with advancing technology.

Fully as important as the natural resources are earth elements subject to use *in situ:* climate, landforms, and soil. They have shaped the course of agriculture and husbandry. Land routes have been generally laid down, and focal sites selected, in conformance to these all-pervading aspects of nature. The Four Historical Areas are notably fortunate in their climate, landforms, and soils.

The earth basis of technology includes also three immaterial items which form the conceptual and practical substructure of the material elements named in the preceding two paragraphs: (1) The size of a habitat affects the range of group action directly, and also indirectly, because the diversity of conditions tends to vary with area. Societies in the vanguard of history have generally increased the size of their functional habitat. (2) The shape of an area may set the trend of its history, as did the narrow, ribbonlike Nile Valley throughout the long record of Egypt. (3) The location of anything has much to do with its utility and so with history. Potentially valuable resources may be useless because they are remote, while others, less rich, but ready to hand, are used. The historical centers have always been favorably located during the period of their ascendancy.

Successful human societies are likely to have an abundance and a variety of natural resources, a favorable climate and terrain, a suitable area, shape, and location. Also they generally need a long lease of time in which to capitalize their environment.

LECTURE II

Interrelations of Geography and History in Critical Historical Movements

To understand how geography and history are interrelated, it will be helpful first to consider typical and important sorts of historical movements, in order to show precisely how nature has conditioned them.

Geography in Wars

One such type of historical sequence is war. In warfare the interactions of space and time are sharply focussed.

In tactics the specialized technology of warfare is brought to bear upon a point on the earth's surface at a moment of time. The successful officer must have a clear concept of the geography of the battlefield (whether on land, at sea, or in the air), including changes resulting from variations of weather. He must also have a canny sense of timing, and ingenuity in using nature to abet his movements.

The realm of strategy is larger than the field of tactics. More area is included in a strategic plan, and more time is required for its execution. Sheer space has much to do with whether a contestant relies on defense or pushes the offense. Climate can never be disregarded. On land, terrain modifies the effect of space; water plays a critical part in several ways; vegetation cover must be taken into account.

The functioning of the natural environment in warfare has altered surprisingly little throughout the ages. The scale of operations has increased and fighting has been extended into the air and under the sea. The changes appear in the incidence of battles rather than in any new effects of the environmental elements involved.

Geography in Major Historical Progressions

In peacetime historical movements the rules are less definite than in warfare, but no less operative. Nature plays its unrelaxing role in human destiny.

The major historical progressions from one epoch to another are associated with changes in technology of the first order of magnitude.

In the occidental world the progression from the medieval to the modern period was based on a shift of areas and habitats. Medieval history concerned itself with western and central Europe, a peninsula of Asia, hemmed in by human enemies on land (to the east and south), by ice to the north, and by unknown ocean to the west. In modern history the European core remains, but it stands open to the six oceans. To it have been added Eastern Europe, the Americas, Africa, and Australia. Even Asia has recognized European leadership.

This change was based squarely on technological advances. The oceanic explorations were made possible by the mariner's compass, the sextant, the hypothesis of a spherical earth, the conviction that Africa could be circumnavigated, and the theory that heat and drouth did not progressively increase southward.

Other technological changes were less immediate, but just as fundamental. The countries which pushed exploration were those which had recently achieved national coherence based on the physical subdivision of Western Europe into units of modest size. The indented coastline and the numerous navigable rivers of Europe fostered overseas and internal commerce. Commerce brought new products from overseas, created a non-agricultural trading population in Europe, and stimulated a major progression in agriculture there —the change from the unfenced, three-field system to that of enclosed fields and pastures.

Two hundred years later the environmental base of occidental society was further widened by the historical progression known as the Industrial Revolu-

tion. This involved many inventions in material techniques, based on a new use of coal and iron ore. Steel and steam made possible the factory system, rapid transportation, and large-scale production of crops with the aid of machinery. Iron and coal opened the way for new uses of other minerals and for the introduction of several minerals hitherto unused.

Consistent advances on the material side of technology since the end of the Middle Ages have led many to assume that progress is inevitable. Actually, under some circumstances, decline may occur. The major historical progression from ancient to medieval history involved a retrogression in material technology. The unit areas of society became smaller, and the utility of natural resources was thereby impaired. Europe shifted from commercial to subsistence economy, population dwindled.

Geography in Mass Migrations

Another type of historical movement closely connected with the natural environment is large-scale migration. The first effect of such a shift is to alter relative densities of population over the earth. The regions affected experience a change in productivity. Life in a new environment compels inventiveness. The immense and prolonged migration from Europe which created the new world of the Americas and Australia produced not only farm machinery and fast transportation, but also a fresh concept of democracy and the right of workers to a decent return for their labor.

Mass migrations occur only when there is a strong stimulus. This may be provided by promising new land, or it may come from a sharpening of discomforts at home. Migration is chronic from niggardly habitats, such as the semi-deserts or rugged mountains. Changes for the worse in any habitat may be launched by man; *e. g.*, famine resulting from the Chinese Revolution of 1911 started a vast movement of North Chinese into Manchuria.

Geography narrowly limits the routes followed in mass migrations. Terrain, cover, water supply, salt, and climate are among the elements of nature that affect overland routes. Movements by sea are directed by winds and currents.

Geography and the Rise and Fall of Cultures

Still another historical sequence having geographic connections is the rise and decline of cultures. For simplicity and clarity, we may confine our consideration to the political aspect of culture.

The coherence and longevity of a state are conditioned by prevalent technology. If it changes materially, the state may disappear. European nations of today grew up when communication was slow and numerous barriers separated the continent into semi-isolated units, each of which differed from the others in part because its habitat was distinctive. The political pattern of North America, in contrast, grew up and took form in the age of canals, stagecoaches, and railroads. The changes associated with the commercial, agricultural, and industrial revolutions have found the United States and Canada adaptable, but they have subjected European states to increasing strains along the many political boundaries. A state containing a large quantity and variety of natural resources can more easily ride the waves of

technological change than a state which lacks critical elements, or one which possesses one or two very valuable resources but is too small to hold them against covetous and powerful neighbors.

LECTURE III

Interrelations of Geography and History in Critical Environments

Each element of the natural environment tends to condition history in its own distinctive way. Where a single facet of nature dominates a habitat, life is hard and history is negligible; *e. g.*, low temperature and consequent restriction of food supply to animal life (mostly pelagic) has narrowed the annals of the eskimo to a heroic effort to keep alive.

In most parts of the earth several elements of the environment create a concurrence of force which tends to encourage a particular choice among several courses of human action, but does not enforce any one of them. In such regions it is difficult to separate one environmental element from the rest and assay its role in history. A canvass of earth conditions nevertheless brings out some universal tendencies.

History and Natural Resources

The history of any group of people rests on the combination of natural resources to which it has access. Those most available lie within the area occupied. Others may be imported, if they can be paid for with surplus resources. The most advanced populations have always lived in regions well endowed with plants, animals, and minerals. But to be serviceable their utility must be understood; an unrecognized resource has no value. The shift in location of leading societies can be explained, up to a point, by advancing technology which demanded natural resources not available to the outmoded habitat. Early societies were small, and isolated by physical barriers. Few resources were available to any one social group, and much of the existing wealth of a region was locked away from its inhabitants by the crudity of their technology.

Early technological achievements of a high order were domestication of animals and cultivation of plants. Except perhaps for Australia, each subcontinent had a wild plant that could be utilized as a staple human food: taros in Malaya; rice in South China and in India; tropical yams in South Asia; grain sorghums in trans-Saharan Africa; millet in Egypt; wheat in Mesopotamia; rye in East Europe; potatoes in Chile and Peru; maize in the Northern Andes; manioc in humid Brazil.

Domesticable beasts were less widespread. None appears to have existed in Australia and Africa, and none in lowland America, although the llama, an unsatisfactory work animal, was available to the high Central Andes. All the others originated in the Eurasia. This leads to a presumption that Asia and Europe reached civilization early in part because human muscle was redoubled by that of animals, and the diet was augmented by a reliable meat supply.

Useful minerals are even more restricted in distribution than domesticable

animals. Furthermore, they are unrelated to environments otherwise favorable to human progress, because they are inherited from the very different earth of past geological ages. Even where they exist they are likely to remain undiscovered because deeply buried. When found they may remain useless unless they occur in conjunction with other minerals which alone can render them useful. Both copper and tin are needed to make bronze, and steel was not produced on a large scale until iron ore and coal were found in juxtaposition.

The lack of correspondence in the distribution of available minerals and population appears doubly important when we realize that the technology of every age is stamped with the stage of advancement in using tools and weapons, both of which are mainly mineral products. Stage of civilization is implied by such terms as stone age, bronze age, iron age, steel age.

No one of these ages has been contemporary in the several continents. With the assimilation of the earth into a single economic unit in modern times all peoples at last have access to all natural resources. Nevertheless, some still lag while others lead. It is clear that time alone will not suffice to bring all societies abreast, because nature has not been even-handed in distributing its bounty.

The range of every crop is rigidly limited, and the ideal variety may not be available in some regions. The staples which do well in the humid low latitudes are high in starch but low in proteids and vitamins. People who must subsist on them remain at a permanent disadvantage. Domestic animals are more tolerant than plants, and therefore have a wider range. But none is suited to every terrestrial habitat. Central Africa lacks every kind of work animal because none can survive infection by the tsetse fly. Minerals are jokers in the game which mankind plays with nature. Possession of the right combination of mineral resources at the right time accounts for some of the most erratic chapters of human history.

History and Climate

In contrast to the natural resources, which man uses or abuses, is climate, on which man has no effect. People who occupy adverse climates remain backward because they spend all their energy on the formidable job of staying alive. Geography suggests that very early man probably lived in tropical lowlands and low uplands. But history has not been made in such climates, nor in extremely cold areas. A golden mean of comfort with rigor appears to have stimulated technological progress.

The four cradles of history were dry lands. Subsequently they were superseded by humid lands, and today they are subordinate within culture-areas controlled by denizens of humid regions. This shift has occurred in all four Major Historical Areas, in spite of differences between the four in landforms, natural vegetation, animal life, and even temperature, a phase of the climate itself.

The progress of civilization from dry lands to humid lands has taken every direction. From North China it moved south and a little east. From the Indus it thrust both east and south, about equally. Within highland America

the direction was southward, and the nearby humid lands were never effectively joined to the cradle lands. The civilization originating in Egypt moved north, then west, then east, and then south and west. The only generalization possible is that the most extended migrations appear to have drifted, with many zigzags, from warm lands to cool lands. This drift has been abetted by improvements in the technology of shelter, food, clothing, and fuel.

The operation of climate on history has been widespread and unremitting. When a human group learned to cope with a particular sort of climate, it was ready to extend its range to correspond with that climate. A notable case is that of the British Commonwealth of Nations.

History and Landforms

The effect of landforms on historical processes is more local than that of climate. Some types of terrain are always handicaps to human progress. Extreme ruggedness reduces arable or otherwise usable land and restricts communication. Ranges constitute a bar to movement and expansion, in ratio to their height, continuity, and density of vegetation cover.

The virtue of a plain is partly determined by surrounding landforms. A ring of protective hills or mountains aids in the consolidation of human society on the plain. If the highlands are not too formidable a barrier, they may be overpassed with advancing technology, and so never became a serious handicap. The inner Paris Basin afforded shelter to nascent France, but later remained as merely the nucleus for a unit of society many times as large. Indeed, the concentric rings of hills which surround Paris gave the denizens of the region a military advantage over their neighbors which was not lost until the perfecting of the airplane, and perhaps not then.

When a landform ceases to function in its traditional manner momentous historical changes may result. The barbarians invaded the Roman Empire across age-old "barrier" rivers and associated valleys, and destroyed the Roman mold of society. Conceivably, the failure of traditional landform barriers to hold back the German armies during the present conflict may be the prelude to another basic alteration in the pattern of European history.

History and the Sea

The role of oceans and large seas in history is unique. They play a simple part, but at a point in the record, their effect is suddenly reversed.

In early ages seas such as the Mediterranean separated and isolated peoples who lived on opposite shores, and the oceans were insuperable barriers to human movement and communication. As a result the subcontinents developed independently, their only connection being slow, dangerous, and little used overland routes. By these trails a dribble of goods drifted from one subcontinent to another, but there was no transfer of people and only garbled and fragmentary accounts made their way across the void. The prehistoric settlement of the earth must have been accomplished by incredibly slow migrations, taking perhaps a million years. Even the relatively recent movements across the Pacific into the Americas and Polynesia are lost to historical record.

At some moment in the classical history of the Mediterranean World people learned how to cross their sea. At once it ceased to isolate and became a unifier. A long succession of wars followed in the course of making the newly recognized natural unit function as an economic, social, and political unit.

With the discoveries of the fifteenth century, this sequence was repeated on the vastly larger scale of the entire earth. Current history affords melancholy proof that most human societies have not yet learned the inescapable lesson of world-unity, imposed by the world-wide continuity of the navigable oceans.

History, and Size and Shape

The size of historically important areas has tended to increase although not steadily. Early history was made by small, self-contained units which were sufficiently separated from outside areas to become seats for coherent and therefore effective social groups. The island of Crete is a case in point. Oases in the desert are likewise small and isolated habitats. Some of them have seen centuries of brilliant history. The Roman Empire marked a culmination in size, and it has thrown its shadow down the ages. After Rome's heyday there came a setback. Not again until the eighteenth century did very large units begin to make history.

The shape of a physical unit large enough to have historical importance affects its internal communication. The efficiency of movement within the area affects its integration. A long, narrow unit, such as the ribbon-like Nile Valley which constitutes Egypt, is awkward to administer. Historic Egypt repeatedly broke up as a result of revolt originating in the end of the country farthest from the seat of administration. External enemies find it easy to take advantage of an awkward shape to attack vulnerable points along the boundaries.

Neither the size nor the shape of a unit is always what it seems. Canada appears on a political map to be very large and also blocky. In geographic and historical reality, it consists of five separated areas of denser population along the United States border, to which all the sparsely peopled remainder is tributary. Actually this vast northland is a world to itself, and has contributed very little to Canada's history.

History and Location

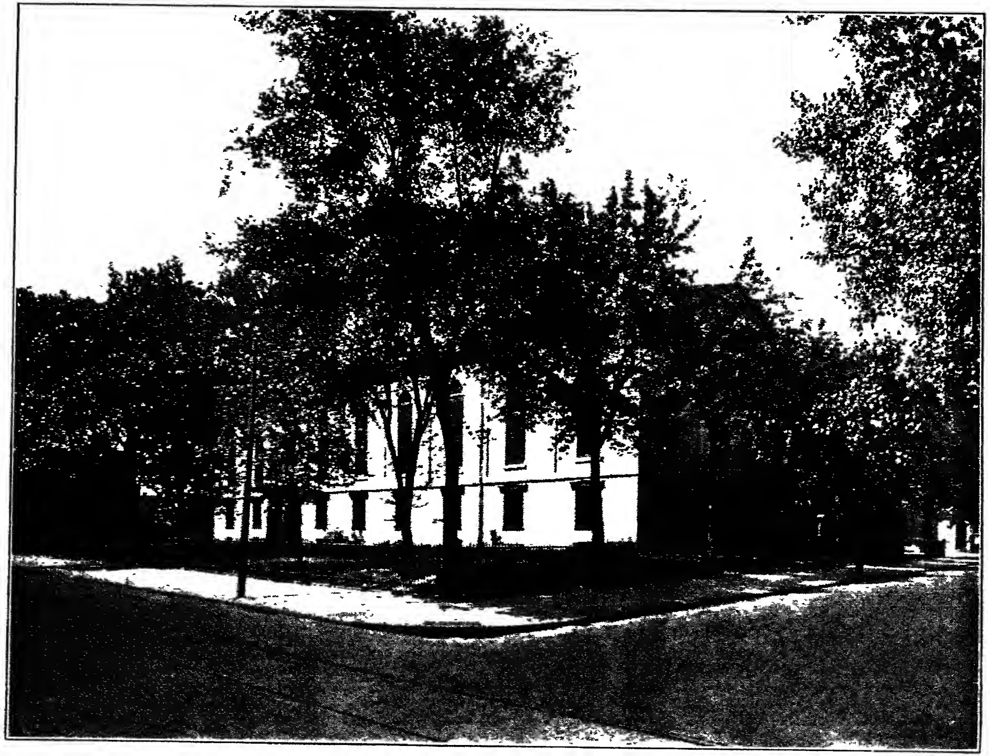
Location, the basic geographic concept, has affected history continuously and in complex ways, but almost unnoticed. Abstractly, expressed in latitude and longitude, location has no meaning. It takes on significance only when we can relate it to other items of nature or culture. The colorless crossing of parallel 40° N. with meridian 75° W. comes alive when we know that it lies just across the Delaware River from North Philadelphia. And the more intimate one is with Philadelphia and its environs, the more meaningful is this statement of location.

The character of a locale may be somewhat changed by human acts. To the Amerinds the swampy flat near the head of Lake Michigan was a rather poor hunting ground. To us it means Chicago and Gary.

In spite of such changes, much of the significance of a location remains unaltered throughout the ages. If history repeats itself, it does so because the natural environment in certain critical locations continues to hold a specific importance for every people of every age. The Dardanelles and Bosporus, subject of daily newspaper bulletins today, have repeatedly taken the spotlight: in the Trojan wars; when the Roman capital was removed to Constantinople; at the capture of that city by the Turks; during the Gallipoli campaign of 1915; and again now. Here is the crossing of a major land-route between Asia and Europe with a major water route between the Atlantic and the inmost recess of the Mediterranean Sea. Over and over a conflict of interests arises between the people who wish to use and control the land-route and those who equally desire to use and control the seaway. Always this conflict is localized at the crossing of the routes.

Location is perhaps the geographic touchstone to history. But it is nothing without the other elements of the natural environment. Human history is an exciting record. When based on an understanding of geography it becomes the absorbing unfoldment of man's progress in his varied habitats. In a very real sense history records the struggles of mankind to shape nature to his own ends. At the same time it depicts human destiny being itself molded by the never relaxing conditions of the earth to which mankind is inexorably bound. History is not the record of man's control of nature. Nor is geography the story of nature determining man's actions. Rather history and geography together give us a profoundly moving account of the collaboration of animate man and inanimate nature.

Harvard University.
March, 1941.



THE WAGNER FREE INSTITUTE OF SCIENCE

BULLETIN

of the

WAGNER FREE INSTITUTE OF SCIENCE

PUBLISHED BY THE INSTITUTE

SYDNEY L. WRIGHT, *Editor*

Vol. 16 — Quarterly — $1.00 per year
No. 3 — AUGUST, 1941 — Single numbers, 25 cents

HISTORY

The Wagner Free Institute of Science was founded in 1847 by William Wagner, a citizen of Philadelphia.

In his early life William Wagner became associated with Stephen Girard in the extension of Girard's mercantile business. While in Girard's employ he had the opportunity to visit foreign countries, and being interested in scientific pursuits, he made a study of scientific institutions abroad and collected natural history specimens which afterward formed the nucleus for the collections in the museum of the Institute.

The Institute, itself, had its inception in a series of free lectures delivered by Professor Wagner in his home. These lectures, begun in 1847, were continued until 1855 when the Institute was incorporated by act of legislature.

A large measure of credit is due Mrs. Louisa Binney Wagner, Professor Wagner's wife, for sympathy, understanding and active coöperation in the early days of the founding of the Institute.

In 1855 a faculty was appointed and the work was continued in a new location at 13th and Spring Garden Streets, the City of Philadelphia giving permission for the use of Commissioners' Hall. Some years later Professor Wagner decided to erect a building on the present site at Seventeenth Street and Montgomery Avenue. This building was completed in 1865 and occupied immediately.

William Wagner died in 1885 and the management of the Institute was transferred to a Board of Trustees.

In 1901 a wing was added to the building for the use of a branch of the Free Library of Philadelphia.

INSTRUCTION

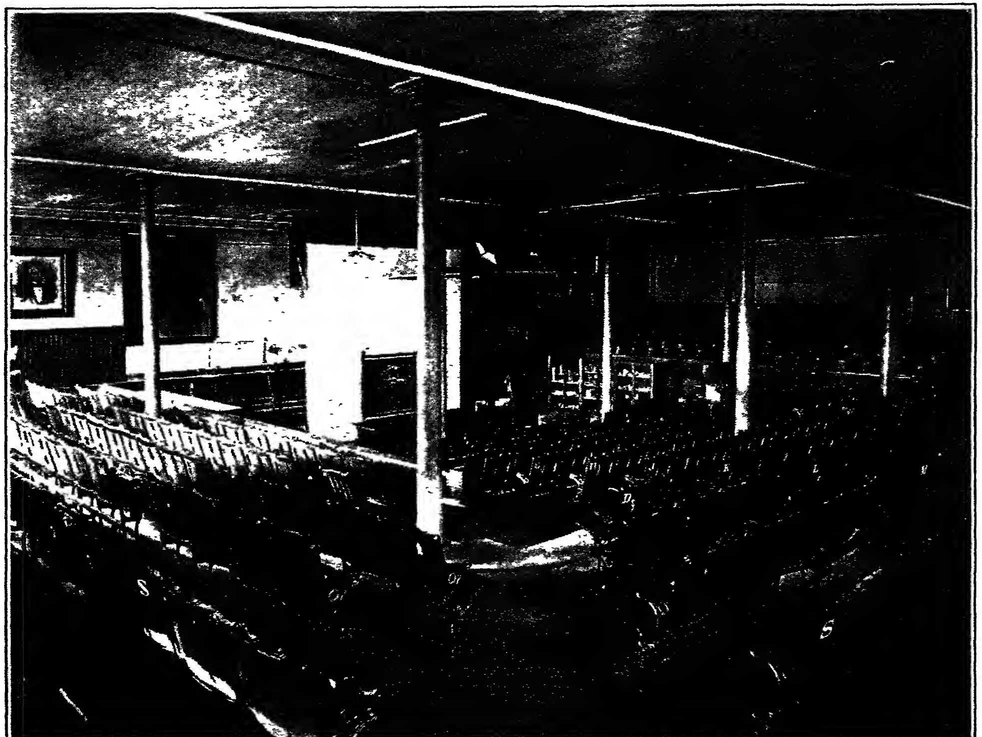
Lectures and Class-Work

Instruction at the Wagner Free Institute of Science is conducted by means of lectures supplemented by class work. There are no tuition fees.

Persons may attend lectures without registering for the classes if they so desire. Those registering for the classes are required to hand in a weekly paper and are admitted to an examination at the end of the term. Those persons successfully passing the examination are awarded certificates for the year's work.

There are seven courses of scientific lectures covering a period of fourteen weeks each for four years. On the successful completion of four years' work a Full Term Certificate is awarded.

The closing of each lecture season is marked by Commencement Exercises.



AUDITORIUM

Museum

Museum

The Institute maintains a natural history museum containing more than 21,000 specimens illustrating the various branches of natural science.

The collections are arranged especially for study. The museum is open to visitors on Wednesday and Saturday afternoons from 1 P.M. until 4 P.M., except legal holidays.

On each Monday evening at 7 P.M., from September to May, a "Museum Talk" is delivered in the museum, the speaker using the specimens in the museum to illustrate the lecture.

Teachers and students desiring to use the museum for special studies will be admitted upon application at the office.

Libraries

The Reference Library of the Institute contains over 25,000 bound volumes and approximately 150,000 pamphlets on scientific subjects, classified and arranged for ready reference. There are also many foreign and domestic periodicals on file. The library is open to the public as well as to students from 10 A.M. to 9 P.M., Monday through Friday. Saturday, 10 A.M. to 5 P.M.

The Free Library of Philadelphia maintains a branch library in the building, known as the Wagner Institute Branch, from which books may be taken out under the rules of the Free Library.

Publications

The publications of the Institute consist of three series:

Transactions: begun in 1885 and discontinued in 1927.

Publications: succeeding the Transactions. These Publications are issued at irregular intervals.

Bulletin: issued quarterly.

SPECIAL LECTURES

Westbrook Free Lectureship

The Westbrook Free Lectureship is supported by the income from an endowment provided by Dr. Richard Brodhead Westbrook and his wife, Dr. Henrietta Payne Westbrook. The lectureship was established in 1912 and provides for one course of lectures each year. These lectures cover a wide range of topics and a list of those so far given may be found on page 34.

Fannie Frank Leffmann Memorial Lectureship

The income of a fund given by Dr. Henry Leffmann is applied to occasional special lectures under the Memorial Lectureship. These lectures are popular in character.

The *Philadelphia Natural History Society* is affiliated with the Institute and holds meetings on the third Thursday of each month from October to May.

RESEARCH

The Institute has carried on research work since 1885 in various departments of science. Results of research have been published from time to time in the Transactions, Publications and Bulletin.

The Institute is also the recipient of the income from two funds established by Dr. Henry Leffmann. This income is devoted to research in chemistry.

CERTIFICATES AWARDED AT CLOSING EXERCISES, MAY 14, 1941

FULL TERM CERTIFICATES

BOTANY
E. Francis Hervey
Daniel Hofheimer
Mary H. B. Schrack

INORGANIC CHEMISTRY
Frank Rush
Samuel Shober
Raymond S. Whitehead

ORGANIC CHEMISTRY
Samuel Shober
Raymond S. Whitehead

ENGINEERING
Beecher Finch
Louis S. Langford
John F. McDevitt

ZOOLOGY
Samuel Shober

GEOLOGY
Albert H. Petri
Samuel Shober

PHYSICS
Edwin Hahn, Jr.
Samuel Shober

1940-1941 CERTIFICATES AWARDED

BOTANY 2

Anthony Albrecht
Kitson A. Broadbelt
Joseph M. Devlin
Fred J. Duke
Marie M. Fortin
E. Francis Hervey
John Hofferbert
Daniel Hofheimer
Agnes McFarland
Helen Ramsay
Caroline Reed
Mary H. B. Schrack
Samuel Shober
George F. Stauffer
William M. Thompson, Jr.
Robert W. Tuckey
Gertrude A. Vieweger
Agnes R. Zimmer

INORGANIC CHEMISTRY 4

Adolph W. Awot
Harry Boris
Paul A. Lockrey
Joseph A. Meuser
Rudolph P. Meuser
William B. Reiff
Frank Rush
Samuel Shober
William M. Thompson, Jr.
Albert J. Wallace, Jr.
Raymond S. Whitehead

ORGANIC CHEMISTRY 4

Robert L. Johnston
Clarence Mosby
Peace Paubionsky
William B. Reiff
Milton R. Sheen
Samuel Shober
Richard Walters
Raymond S. Whitehead

ENGINEERING 2

Lorenzo V. Blackston
William H. Brown
William H. Conley
Beecher Finch
Paul A. Fisher
John W. Grieb, Jr.
William Heck
Robert L. Johnston
Louis S. Langford
David Leslie
John F. McDevitt
Raymond C. Patton
William A. Reese
George H. Shandle
F. Howard Shank
Samuel Shober
Thom A. Street
Norman T. Wineke

ZOOLOGY 1

Nelson P. Bolton
Joseph M. Devlin
Dorothy R. Heritage
Agnes McFarland
Julia A. Noecker
Kenneth J. Noecker
Samuel Shober
Gertrude A. Vieweger

GEOLOGY 2

William H. Conley
Joseph M. Devlin
Belle Fryer
Harriet D. Gammell
Arthur Jaffe
Albert H. Petri
Helen Ramsay
M. Dorothy Reed
Albert Schwabeland
Samuel Shober
Helen Shoemaker
Clarence Strohm
Charles S. Thompson
Albert J. Wallace, Jr.
Charles I. Wilkinson

PHYSICS 3

Adolph W. Awot
William H. Conley
Leroy W. Ferber
Arnold Golden
Edwin Hahn, Jr.
Doris F. Horn
Robert L. Johnston
Arthur Klein
Paul A. Lockrey
Benjamin J. Patton
Arthur G. Paul
William A. Reese
William J. Schuele
Samuel Shober

FACULTY

JOHN WAGNER, Jr.

B.S. in C.E. 1913, University of Pennsylvania.
C.E. 1920, University of Pennsylvania.
1913–1916, Draftsman, Phoenix Bridge Company.
1916–1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921–1926, Assistant Supervisor Track, Reading Company.
1926–1928, Supervisor Track, Reading Company.
1928–1936, Industrial Agent, Reading Company
1936 to date, Assistant General Freight Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899–1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906–1915.
Head of Science Department, Germantown High School, 1915–1923.
Principal, Roxborough High School, 1923–1924.
Principal, Germantown High School, 1924 to date.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906–1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:
"Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
"Ether Waves and the Messages They Bring," Transactions of the Wagner Free Institute of Science.
"The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900–1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901–1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916–1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921–1937.
Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.
Dean of the Faculty.
Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Sc.D. (Hon.), Bucknell, 1934.
Director of Research, John B. Stetson Company, 1925 to date.
Director of Laboratories, Stetson Hospital, 1920 to date.

Editor, American Journal of Pharmacy, 1921–1941.
Dean of Pharmacy, Philadelphia College of Pharmacy and Science, 1938 to date.
President, Philadelphia College of Pharmacy and Science.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Fellow of the Royal Society of Arts, London, Eng.
Member American Chemical Society.
Member American Pharmaceutical Association.
Member Penna. State Board of Health.
Publications:

"Recent Remedies," 1926 (revised 1928). International Publications, N. Y.
"Popular Science Lectures" (Editor). Phila. College of Pharmacy and Science, Phila.
U. S. Dispensatory (Collab. Editor). Lippincott, Phila.
Formula Book, A. Ph. A. (Editor). Lippincott, Phila.
A Science Miscellany, International Printing Company, Phila.
Contributor to current chemical, pharmaceutical and medical literature.

GEORGE BRINGHURST KAISER

Educated in private schools.
Graduate, Franklin School.
After graduation spent several years in intensive botanical study and field work in northeastern United States.
Secretary of the Botanical Society of Pennsylvania for seven years and leader of its field trips.
Professor of Botany, Wagner Free Institute of Science, 1927 to date.
Curator, Moss Herbarium, Sullivant Moss Society.
Member, Academy of Natural Sciences.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology and Stratigraphy in Princeton University.
Lecturer on Paleontology and Geology, University of Pennsylvania.
Acting Curator, Department of Paleontology, Academy of Natural Sciences of Philadelphia.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Secretary of the International Paleontological Union.
Editor of the section of General Paleozoology of *Biological Abstracts.*
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, Colorado School of Mines, as a consulting paleontologist and research associate.

REGULAR LECTURES, SESSION OF 1941–1942

BOTANY 3

PROFESSOR KAISER

Taxonomy

Lectures begin at 8 P. M.

1. Monday, September 8.
   Gramineae. Cyperaceae. Usefulness of grasses as food for man and beast and their exceeding beauty. The legion of sedges large and small.

2. Monday, September 15.
   Palmae. Araceae. Majestic and beautiful palm trees that subserve many uses. Showy aroids—Taro or Dasheen, Delicious Monster, Anthurium. Sweet Flag.

3. Monday, September 22.
   Liliaceae, Amaryllidaceae, Iridaceae. Tulipa, Star of Bethlehem, Squill, Hyacinth, Lily-of-the-Valley, Hippeastrum, Crinum, Snowdrop, Iris and Crocus.

4. Monday, September 29.
   Orchidaceae. A wealth of lovely orchids—Cattleya, Laelia, Vanilla, Odontoglossum, Dendrobium, Phalaenopsis, Vanda and others.

5. Monday, October 6.
   Betulaceae, Fagaceae, Ulmaceae. The graceful Birch, Alder, Hazel, Hornbeam, Beech. Oaks. Monarch of the forests.

   Monday, October 13. No lecture.

6. Monday, October 20.
   Ranunculaceae, Nymphaeaceae, Magnoliaceae. Buttercups, Meadow Rue, Anemone, Clematis, Columbine, Larkspur, Peony, Water Lilies and beautiful Magnolias.

7. Monday, October 27.
   Papaveraceae, Cruciferae. Poppies. Celandine, Prickly Poppy, Mustard, Turnip, Rape, Cress, Madwort, Candytuft. Radish.

8. Monday, November 3.
   Rosaceae. A great family of beautiful garden flowers and delicious fruits of the orchard. Roses, Cinquefoil, Strawberry, Raspberry, Brambles, Exochorda, Spiraea, Ninebark, Plum, Peach, Quince, Pear and Apple.

9. Monday, November 10.
   Leguminosae. The great Pea Family, comprising herbs, shrubs and trees. 450–500 species of rare beauty for ornament and delicious as food.

10. Monday, November 17.
    Umbelliferae. Aralaceae, Cornaceae. The great group of umbel-bearers. Cumin, Coriander, Dill, Fennel, Parsley, Celery, Parsnip, Chervil, Hercules' Club, Ginseng. Ivy and the Dogwoods.

11. Monday, November 24.
    Solanaceae, Scrophulariaceae. Nightshades, Potato, Eggplant, Jerusalem Cherry, Tomato, Bella Donna, Winter Cherry. Henbane, Tobacco, Speedwell, Foxglove, Empress Tree, Monkey Flower.

12. Monday, December 1.
    Rubiaceae, Caprifoliaceae. Bedstraw, Buttonweed, Partridge Berry, Buttonbush, Quaker Lady, Honeysuckle, Snowberry, Twin-flower, Horse Gentian, Viburnum, Elder.

13. Monday, December 8.
    Cucurbitaceae. Gourd, Squash, Pumpkin, Luffa, Watermelon, Cucumber, Cantaloupe, Cassaba, Serpent Melon, Chayota, Momordica, Bryony, Ecballium, the Squirting Cucumber.

14. Monday, December 15.
    Compositae. The great Composite Family-crown of the vegetable kingdom. Ironweed, Thoroughwort, Gum-plant, Golden Aster, Golden-rod, Chicory, Salsify, Dandelion, Lettuce, Hawkweed, Yarrow, Chrysanthemum, Tansy, Wormwood, Coneflower, Sunflower, Dahlia, Daisy, Aster and many other Genera and Species.

Field Trip

The class in Botany will be conducted on a field trip under the leadership of Professor Kaiser. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

INORGANIC CHEMISTRY 1

PROFESSOR HORN

General Principles and Theories
Notation: Non-Metals

Lectures begin at 7.45 P. M.*

1. Tuesday, September 9.
   Scope of Chemistry. Matter, and its changes. Physical and chemical properties. Contact, an essential for chemical change. Adsorption. Three states of Matter. Conservation of Matter. Conservation of Energy.

2. Tuesday, September 16.
   Chemical Classifications. Chemical Elements. Composition of the earth's crust, of the sun, and of plants and animals. Metallic and non-metallic Elements. Chemical Compounds, binary, ternary, etc.; acids, bases, salts, and other compounds. Polar and non-polar compounds. Homogeneous and heterogeneous Systems. Mixtures, and their components; solutions, alloys and other mixtures.

3. Tuesday, September 23.
   Atomic Theory. The fundamental laws of chemical combination. Explanation of Definite, Multiple and Reciprocal Proportions. Chemical Symbols and other features in the short-hand of Chemistry. Thermal values in chemical changes; in physical changes. The atom as a complex unit, protons, electrons. Chemical Atomic Weights as statistical averages of the isotopes of the Elements.

4. Tuesday, September 30.
   Hydrogen. Occurrence, preparation, properties. The lightest and least complex atom. The freeing of hydrogen by other Elements and by the electric current; the Chemical Equivalent and the Electro-Chemical Equivalent of an Element. Graham's Law of Diffusion. Hydrides. Hydrogenation. Varieties and isotopes of hydrogen.

* Please note the hour.

5. Tuesday, October 7.

   Oxygen. Occurrence, preparation, properties. The most convenient basis for Chemical Atomic Weights. Oxidation; heat of combustion, kindling temperature, explosion. Oxy-hydrogen and oxy-acetylene flames. Oxides; acidic, basic, and neutral. Peroxides and dioxides. Allotropic oxygen, ozone. Isotopic oxygen. Atomic Numbers.

6. Tuesday, October 14.

   Properties of Matter in the Gaseous State. The Gas Laws. The General Gas Equation. The Gas Constant. Gay-Lussac's Law of chemical reaction of gases. Avogadro's Hypothesis; Avogadro's Constant. Molecular Weights. Valence, the ratio between Chemical Equivalents and Atomic Weights.

7. Tuesday, October 21.

   Uses and Variations of Chemical Symbols and Formulas. Origin of the symbols. Symbols of isotopes. Formulas of molecules of Elements: allotropes. Formulas of molecules of Compounds: isomers. Chemical equations, and chemical change. Thermal and electrolytic dissociations of molecules. Formulas of ions and of radicals.

8. Tuesday, October 28.

   Chemical Forces. Electron orbits and the displacement of electrons. Atomic nuclei; their gains and losses. Transmutations of the Elements. Chemical Statics; Equilibria. Chemical Kinetics; Rates; Law of Mass Action. Photo-chemistry. Thermo-chemistry.

9. Tuesday, November 4.

   Water and Hydrogen Peroxide. Importance of water to chemical change, and to life. Analysis and synthesis of water. Purification of water; its dissociation constant, hydrogen ion concentration, and pH value. Reactions of water in combination, decomposition, displacement, and metathesis. Heterogeneous equilibria in Systems the sole component of which is water; the Phase Rule. Preparation and properties of hydrogen peroxide.

10. Tuesday, November 11.

    Electro-Chemistry. The Displacement Series. Faraday's Laws. Electrochemical Equivalents. Arrhenius's Theory. Activity coefficients; strong and weak electrolytes. Electrolytic dissociation as an explanation of neutralization, hydrolysis, oxidation and reduction, displacement, and precipitation. Reactions that go to completion.

11. Tuesday, November 18.

    Principal Types of Inorganic Groupings. Oxides, anhydrides, halides, sulphides, radicals, salts of oxygen acids, salts of more than one base, normal salts, acid salts, basic salts, double salts, complex ions, complex salts. Partial anhydrides.

12. Tuesday, November 25.

    Physical-Chemical Considerations. Solubility of solids in liquids; unsaturation, saturation, supersaturation. Crystalline and amorphous solids. Osmotic pressure of non-electrolytes and of electrolytes. Colloids and colloidal solutions. Other cases of solubility.

13. Tuesday, December 2.

    Air. History. The coined work, "gas." Troposphere and stratosphere. Liquid air; its use as a source of industrial products. Air a mixture, not a compound. The atmosphere as essential to life of plants and animals. Life processes involving constituents of the air; permissible variations in the composition of the air in enclosed spaces. Bacteriology of the atmosphere. Elements of Air Conditioning, as determined by human comfort.

14. Tuesday, December 9.

    Nitrogen. Occurrence, preparation, properties. Relation to life; the Nitrogen Cycle. Nitrogen values in water analysis. Dalton's Law of Partial Pressures; Dalton's Law of Solubilities of mixed gases. Commercial fixation of nitrogen as ammonia, as oxides of nitrogen, as cyanamide. Nitrogen in explosives. Hydrazine, hydrazoic acid, and nitrides.

ORGANIC CHEMISTRY 1

PROFESSOR GRIFFITH

General Principles: Aliphatic Hydrocarbons and Derivatives

Lectures begin at 8 P. M.

1. Wednesday, September 10.
   Nature and Composition of Organic Matter. Distinctions between the terms organic and inorganic. 1828—Wohler's discovery of urea synthesis—and changed concepts of organic chemistry. The Dawn of Creative Chemistry.

2. Wednesday, September 17.
   The Composition of Organic Matter. Where Carbon is King. Proximate and ultimate analysis. General tests for organic substances.

3. Wednesday, September 24.
   Transformations of Organic Matter in Nature. Fermentation—Putrefaction—Decay. Nature's scheme of circulation. The "ups and downs" of nitrogen.

4. Wednesday, October 1.
   Transformations of Organic Matter in the Laboratory. Destructive distillation, fractional distillation, substitution of elements and groups. Organo-metallic compounds. Builders of molecular structures.

5. Wednesday, October 8.
   Industries Based upon Fermentations of Various Kinds. Alcohol, acetone, glycerol, acetic acid, lactic acid, citric acid. Tanning, brewing, food and dairy industries.

6. Wednesday, October 15.
   Classification and Nomenclature of Organic Compounds. A study in names. Diaminodihydroxyarsenobenzene hydrochloride vs. sodium chloride. Complexity of organic terms necessary; each syllable means something to those who "run and read."

7. Wednesday, October 22.
   Molecular Structure. Isomerism, polymerism, metamerism. Einsteinian chemistry—stereochemistry and optical activity.

8. Wednesday, October 29.
   Hydrocarbons. Principal types. Homologous series. Paraffins (methanes). Petroleum. Gasolines, cleaning fluids and solvents.

9. Wednesday, November 5.
   Paraffins (methanes) (Continued). Natural gas and its derivatives. Coal gas, bitumens, etc.

10. Wednesday, November 12.
    Olefins (ethenes). Derivatives of hydrocarbons. Alcohol radicles.

11. Wednesday, November 19.
    Alcohols. Ethyl and Methyl, the alcohol twins. Proof spirit, denatured alcohols, medicated alcohols, industrial alcohols. Other alcohols used in the arts and industries. Alcoholic beverages.

12. Wednesday, November 26.
    Aldehydes. Acetaldehyde, formaldehyde and their polymers. Their industrial applications.

13. Wednesday, December 3.
    Ethers and Esters. Scent and flavor owe their favor mostly to these twins. Esterification, hydrolysis, saponification.

14. Wednesday, December 10.
    Esters (Concluded). Commercial uses of ethers and esters. Industrial solvents. The great lacquer industry. Imitation fruit flavors.

ENGINEERING 3

PROFESSOR WAGNER

Roads, Railroads and Tunnels

Lectures begin at 7.45 P. M.*

1. Friday, September 12.
   Engineering Location. Surveying. Measuring straight lines. Measuring angles. Field work.

2. Friday, September 19.
   Engineering Location (Continued). Vertical measurements. The "Y" level. Barometer. Topography. Field work.

3. Friday, September 26.
   Roads and Pavements. Definition. Reconnaisance. Preliminary surveys. Maps. Profiles. Location.

4. Friday, October 3.
   Roads and Pavements (Continued). Earthwork. Drainage. Foundations.

5. Friday, October 10.
   Roads and Pavements (Continued). Surfacing. Natural dirt roads. Gravel roads. Broken stone roads.

6. Friday, October 17.
   Roads and Pavements (Concluded). Granite block, asphalt, wood and concrete pavements.

7. Friday, October 24.
   Railroads. Economic location. Railroad curves. Field work.

8. Friday, October 31.
   Railroads (Continued). Earthwork. Drainage. Ballast. Ties.

9. Friday, November 7.
   Railroads (Continued). Rails. Frogs. Switches. Crossings.

10. Friday, November 14.
    Railroads (Continued). Signals: block; interlocking. Turntables. Snow sheds and fences. Rolling stock and locomotives.

11. Friday, November 21.
    Railroads (Continued). Stations. Terminals. Bridges. Elevated railroads.

12. Friday, November 28.
    Railroads (Concluded). Underground railroads. Use of electricity. Street railways. Rack railroads.

13. Friday, December 5.
    Tunnels. Location. Shafts. Heading. Driving in soft ground; in rock. Blasting. Explosives. Ventilation.

14. Friday, December 12.
    Tunnels (Concluded). Cross sections. Packing. Submarine tunnels.

* Please note the hour.

ZOOLOGY 2

Mr. Lawrence

Animals with Endoskeletons and Highly Developed Nervous Systems

Lectures begin at 8 P. M.

1. Monday, January 5.
   Introduction to the Vertebrates. Their ancestors. Their general structure. The internal skeleton and its advantages. The classes of vertebrate animals.

2. Monday, January 12.
   The Part Fish Have Played in the Rise of Life from Mud to Man. Early types of fish found in fossils only. The simplest fish today: lampreys, sharks, and rays.

3. Monday, January 19.
   The Habitats and Adaptations of Fish. Strange forms and many sizes. Numerous offspring and many enemies. Their food.

4. Monday, January 26.
   Frogs, Toads, and Salamanders. Their strange life histories. Their great contribution to animal evolution. How they meet the problems of life. Their value to man.

5. Monday, February 2.
   Reptiles. The first vertebrates to become strictly air breathing. The stories of snakes, lizards, turtles, and crocodiles. An interesting and valuable group of animals that is poorly appreciated.

6. Monday, February 9.
   The Structure and Activity of Birds. Their superiority to all lower forms of life. Many interesting and curious habits. Extinct birds. Birds in relation to man.

7. Monday, February 16.
   Migration and Nesting Habits of Birds. Why birds migrate and how they know the way. Nest materials and forms of nests. The food of young and old birds.

   Monday, February 23. No lecture.

8. Monday, March 2.
   Some Birds of Outstanding Interest. Eagles, hawks, and owls. Birds of great flight. Non-flight birds. Swimmers, waders, and divers. The origin of our domestic birds.

9. Monday, March 9.
   Mammals, the Crowning Glory of the Animal World. Why they are superior to all other life. Their structure and activity. Habitats and adaptations. Their food.

10. Monday, March 16.
    Mammals of Lowest Rank. Mammals that lay eggs. Mammals whose young are carried in pouches. Mammals with few or no teeth. Are they mistakes of nature or do they have a real place to fill?

11. Monday, March 23.
    Mammals That Have Deserted the Land for a Life in Water. Whales, porpoises, seals, walruses, manatees, etc. How they adapt themselves to an element not entirely suited to them. Their value to man.

12. Monday, March 30.
    The Great Group of Carnivorous Animals. Lions, bears, tigers, wolves, martens, foxes, etc. Their value as producers of fur. How their predacious habits tend to promote evolution.

13. Monday, April 6.
    The Great Group of Hoofed Mammals. Horses, cattle, deer, antelopes, sheep, hogs, etc. Their relation to other animals and to man. Factors in the rise of civilization.
14. Monday, April 13.
    Mammals Most Closely Related to Man. Evidences of superior mental ability among the monkeys and apes. Their adaptations, activities, and food. Reproduction and care of young.

Field Trip

The class in Zoology will be conducted on a field trip under the leadership of Mr. Lawrence. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

GEOLOGY 3

PROFESSOR HOWELL

Paleontology

Lectures begin at 7.45 P. M.*

1. Tuesday, January 6.
   How the Book of the Dead was Written. How the record of the life of the Past was made.
2. Tuesday, January 13.
   How we Read the Book of the Dead. How paleontologists decipher the writing in the rocks.
3. Tuesday, January 20.
   Why There is so Little Writing on the Earliest Pages of the Book. Why the shadowy first inhabitants of the Earth left so poor a record.
4. Tuesday, January 27.
   The Writing Grows More Legible. The story becomes clear enough so that we can follow the course of plant and animal evolution.
5. Tuesday, February 3.
   The Main Stems and Branches of the Tree of Life. The great phyla of plants and animals.
6. Tuesday, February 10.
   The Early, Primitive Plants. Long restricted to the water, they finally gain a toe-hold on land.
7. Tuesday, February 17.
   The Later Plants Which Flourished on Land. How the higher plants adapted themselves to life on dry lands.
8. Tuesday, February 24.
   The One-Celled Animals, Ancestors of the Many-Celled Creatures. The tiny Protozoa, from which all the higher animals sprang.
9. Tuesday, March 3.
   The Sponges and Coelenterates. The conservative and the progressive descendants of the protozoans.
10. Tuesday, March 10.
    The Active Worms and the Sluggish Echinoderms. The worms attain bilateral symmetry and the echinoderms lose it again.

* Please note the hour.

11. Tuesday, March 17.

    The Molluscoideans Which Tried Two Kinds of Sedentary Living. The solitary brachiopods and the colonial bryozoans.

12. Tuesday, March 24.

    The Mollusks, The Great Phylum of Shelled Animals. The clams, snails, and nautiloids and their many relatives.

13. Tuesday, March 31.

    The Huge Phylum of the Jointed Legged Animals. The crustaceans, spiders, and insects and their countless cousins.

14. Tuesday, April 7.

    Our own Phylum, the Chordata. The fishes, amphibians, reptiles, birds, and mammals, and their humbler kin.

Field Trip

The class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

PHYSICS 4

PROFESSOR SEELY

Electricity and Magnetism

Lectures begin at 8 P. M.

1. Wednesday, January 7.

   How Man's Knowledge of Electricity Began and How It Grew. Production of stationary charges. The law of attraction and repulsion between charges. Potential and capacity. Action of points. Lightning.

2. Wednesday, January 14.

   How Electric Currents Were First Caused and Controlled. Voltaic Cells. What is an "electric current"? Electromotive force or pressure. Local action. Polarization. Open-and-closed-circuit cells. Thermoelectric cells.

3. Wednesday, January 21.

   The Flow of Electricity in Circuits. Conductivity. Resistance, Pressure and amount of flow. Ohm's Law. Electric units. Specific resistance.

4. Wednesday, January 28.

   The Flow of Electricity in Circuits (continued). Resistance in wire circuits. Circuits in parallel and in series. Shunts. Fall in pressure along a circuit. Connection of cells in parallel and in series.

5. Wednesday, February 4.

   The Flow of Electricity in Circuits (concluded). Heat effects of currents. Electrical work and power. Conservation of energy. Relation of electrical units to those of heat and mechanical energy.

6. Wednesday, February 11.

   The Flow of Electricity through Liquids. Chemical effects. Laws of Faraday. Chemical equivalent and electrochemical equivalent. Voltameters.

7. Wednesday, February 18.

   The Growth of Our Knowledge of Magnetism. Natural and artificial magnets. The law of magnetic attraction and repulsion. Molecular magnetism. Magnetic fields. Terrestrial magnetism.

8. Wednesday, February 25.

   How Magnetisms are Related. Effects of a current on a magnetic needle. Magnetic field produced by a current. Coils and electromagnets. Permeability and reluctance. The magnetic circuit.

9. Wednesday, March 4.

   Getting a Current from a Magnetic Field. A conductor cutting "lines of force." Magnetos. Direction and magnitude of an induced pressure. Action of coils in magnetic fields. Induction coils. Lenz's Law.

10. Wednesday, March 11.

    Instruments for Measuring Pressure and Current. Galvanometers. Voltmeters and ammeters. Wattmeters.

11. Wednesday, March 18.

    How Resistance of Conductors is Measured. Measurement by substitution. Resistance boxes. Wheatstone's bridge. The ammeter-voltmeter method.

12. Wednesday, March 25.

    How Current is Made and Used Commercially. Direct current dynamos and motors. Field magnets. Bi-polar and multipolar machines. Armatures. Commutators. Series, shunt and compound windings.

13. Wednesday, April 1.

    Some Differences Between Alternating and Direct Currents. Representation of currents by curves. Self-induction. Measuring instruments for alternating currents.

14. Wednesday, April 8.

    Some Facts and Some Theories Concerning Electricity and Matter. Passage of electricity through gases. Radium and its products. Molecular nature of electricity.

MUSEUM TALKS

Monday evenings at 7 o'clock

This series comprises informal talks, given on Monday evenings in the Museum, illustrated by specimens.

PROFESSOR HOWELL

Minerals, Rocks and Fossils

Sept. 8. Minerals, the Crystallized Chemical Compounds of Which Rocks are Made.

Sept. 15. Rocks, the Aggregates of Minerals of Which the Earth's Crust is Composed.

Sept. 22. The Minerals and Ores Which are Vital to our Civilization.

Sept. 29. Fossils With the aid of Which we Read the History of the Past.

Oct. 6. Plant Fossils—Stony Seaweeds, Coal, Silicified Logs, and Petrified Fruits.

Oct. 13. No Lecture.

Oct. 20. Animal Fossils—Shells, Bones, and Other Organic Remains Which Tell Us What the Creatures of the Past Were Like.

MISS BORDEN

Birds and Their Place in Nature

Oct. 27. Ancestry—Evolution—Specialization—Structure—of the Bird.

Nov. 3. Fossils and "Living Fossils."

Nov. 10. Birds of the Southern Seas.

Nov. 17. Birds that are Living Jewels.

Nov. 24. Birds that Prey on Their Kind.

Dec. 1. Birds with Beautiful Voices.

Mr. Lawrence

Zoological Problems in Relation to Man's Food Supply

Dec. 8. Rats, Mice, and Rabbits in Conflict with Man over Food.

Dec. 15. Woodchucks, Prairie Dogs, Pocket Gophers, and Squirrels as Farm Pests.

Dec. 22. No Lecture.

Dec. 29. No Lecture.

Jan. 5. Foxes, Weasels, Minks, Otters, Wild Cats, and Bears Like Man's Bill of Fare.

Jan. 12. Wolves, Coyotes, and Pumas Take a Big Toll from Man's Larder.

Jan. 19. Deer, Wild Horses, and Other Grazing Animals That Like Man's Planted Crops.

Jan. 26. Birds That Take Generous Samples of Man's Various Foods.

Mr. Hope

Nature in the Philadelphia Region

Feb. 2. The Geologic Story of the Philadelphia Region. Its Influence on the Plant and Animal Associations of Today.

Feb. 9. Back From the Strand Line—Sea Beach, Dunes and Thicket, Salt Marsh; their Animal Life and Flora.

Feb. 16. New Jersey Bogs and Barrens. Our Backyard Wilderness, Its Plants and Animals.

Feb. 23. No Lecture.

Mar. 2. Penn's (Mixed Deciduous) Woods. Serpentine Barrens. The Life of the North Woods Moved South.

Mar. 9. Plants and Animals of Our Rivers and Streams. The Fens of the Lower Delaware.

Mar. 16. Communities Most Affected by Man. Fields and Waysides. Wild Life in Philadelphia. Our European Fauna and Flora.

Professor Kaiser

Little Journeys in Fields of Botany

Mar. 23. The Thirst for Botanical Knowledge.

Mar. 30. Botany of the Spring.

Apr. 6. Plant Lore.

Apr. 13. Ocean, Lake, Pond and Pool.

Apr. 20. Seaside, Streamside, Valley and Mountain.

Apr. 27. In and about Horticultural Hall and Gardens.

GENERAL SCHEDULE OF REGULAR LECTURES

Subjects of courses in each of the four successive years constituting a full term.

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles and Theories. Notation. Non-Metals.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

ZOOLOGY

1. Invertebrate Animals.
2. Vertebrate Animals.
3. Human Biology.
4. Principles of Animal Life.

BOTANY

1. Morphology.
2. Taxonomy.
3. Taxonomy (continued).
4. Physiology and Ecology.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

LECTURES UNDER RICHARD B. WESTBROOK FOUNDATION

1912.—Ancient Civilization of Babylonia and Assyria. *Morris Jastrow, Jr., Ph.D.*

1913.—Conservation of Natural Resources. *Gifford Pinchot, Marshall O. Leighton, Overton W. Price, Joseph A. Holmes.*

1914.—The Theory of Evolution. *William Berryman Scott, Ph.D., LL.D.*

1915.—Invisible Light. *Robert Williams Wood, LL.D.*

1916.—Aspects of Modern Astronomy. *John Anthony Miller, A.B., A.M., Ph.D.*

1917.—Heredity and Evolution in the Simplest Organisms. *H. S. Jennings, B.S., A.M., Ph.D., LL.D.*

1918.—The Chemistry, Nutritive Value and Economy of Foods. *Harvey W. Wiley, A.M., M.D., B.S., Ph.D., LL.D., D.Sc.*

1919.—The Origin and Antiquity of the American Indian. *Aleš Hrdlička, M.D., Sc.D.*

1920.—Chemistry and Civilization. *Allerton S. Cushman, B.S., A.M., Ph.D.*

1921.—Microbiology. *Joseph McFarland, M.D., Sc.D.*

1922.—Evolution of the Human Face. *William K. Gregory, Ph.D.*

1923.—The Philosophy of Sanitation. *George C. Whipple, B.S.*

1924.—The Distribution of American Indian Traits. *Clark Wissler, A.M., Ph.D.*

1925.—Structural Colors. *Wilder D. Bancroft, Ph.D., Sc.D.*

1926.—The Animal Mind; its sources and evolution. *George Howard Parker, Sc.D.*

1927.—An Interpretation of Atlantic Coast Scenery. *Douglas W. Johnson, Ph.D.*

1928.—The Science of Musical Sounds. *Dayton C. Miller, Ph.D.*

1929.—Volcanoes and Vulcanism. *William B. Scott, Ph.D., LL.D.*

1930.—Present Problems of Evolution. *Edwin Grant Conklin, Ph.D., ScD., LL.D.*

1931.—The Problems of the Origin and Antiquity of the American Aborigines in the Light of Recent Explorations. *Aleš Hrdlička, M.D., Sc.D.*

1932.—Common Sense, Science and Philosophy. *John Dewey, Ph.D., LL.D.*

1933.—Social Relations in Monkey, Ape and Man. *Robert M. Yerkes, A.M., Ph.D., Sc.D.*

1934.—Chemistry and Industrial Progress as exemplified in the Study of Hydrogen and Oxygen. *Hugh S. Taylor, D.Sc., F.R.S.*

1935.—Recent Progress in Astronomy. *Samuel A. Mitchell, M.A., Ph.D., LL.D.*

1936.—Real Lilliputians of the Universe. *Ellis L. Manning.*

1937.—Biology and Social Problems. *Edwin Grant Conklin, Ph.D., Sc.D., LL.D.*

1938.—Emotions and the Social Order. *Frederick H. Lund, A.M., Ph.D.*

1939.—The Making and Mixing of Human Races. *Earnest A. Hooton, Ph.D., B.Litt., Sc.D.*

1940.—Atomic Nuclei and Atomic Transmutations. *Kenneth T. Bainbridge, S.M., Ph.D.*

1941.—Geography and Its Influence on History. *Derwent Whittlesey, Ph.D.*

WESTBROOK FREE LECTURESHIP PUBLICATIONS

Can be purchased through any book-store

Ancient Civilization of Babylonia and Assyria, by *Morris Jastrow, Jr.* J. B. Lippincott Co.

The Theory of Evolution, by *William Berryman Scott.* The Macmillan Co.

Life and Death, Heredity and Evolution in Unicellular Organisms, by *H. S. Jennings.* Richard G. Badger.

Chemistry and Civilization, by *Allerton S. Cushman.* Richard G. Badger.

Fighting Foes too Small to See, by *Joseph McFarland.* F. A. Davis Co.

The Relation of Nature to Man in Aboriginal America, by *Clark Wissler.* Oxford University Press.

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RECEPTACULITES MAMMILLARIS FROM THE ORDOVICIAN TANK HILL FORMATION OF NEVADA

By BENJAMIN F. HOWELL, A.M., PH.D.

Most of the fossils which paleontologists have found in the sedimentary rocks of the earth's crust can be identified and classified without difficulty as the remains of certain kinds of animals or plants. They can be identified and classified because there are still living on the earth species which are so closely related to those whose remains the fossils are that a comparison of the fossils with the living forms discloses their relationships.

But there have been collected from the older Paleozoic rocks some fossils which appear not to have any living relatives. These have proved so difficult to classify that even the specialists who have studied them intensively do not agree as to their nature or their place in the "tree of life."

A number of these puzzling organic remains are so peculiar in form that scientists have not even been able to determine whether they are plants or whether they are animals.

Among the most puzzling—and therefore the most interesting—of this latter group are the strange fossils found in the marine Ordovician and Silurian rocks of various parts of the world which are called the Receptaculitidae, or receptaculitids.

Receptaculitids are sometimes common and well preserved, so that their hard parts can be clearly seen and easily studied. But these hard parts are so peculiar and so unlike those of any other known organisms, living or extinct, that paleontologists are still in doubt as to whether to call them the remains of animals or of the fossils of plants. We can not even be certain whether their hard parts were composed in life of calcium carbonate, or whether they were siliceous, like the skeletons of the siliceous sponges. Various specialists who have tried to classify these queer fossils have considered them to be the remains of sponges, foraminifera, corals, cystoidean echinoderms, and even tunicates, while others have claimed that they were the

fossils of calcareous algae. Most modern paleontologists are undecided about their relationships.*

Because of this tantalizing uncertainty as to their true nature the Receptaculitidae have a special interest for students of the life of the past. But in spite of this fact, only a few good figures of such fossils have ever been published. It therefore seems desirable to illustrate several excellent specimens which were collected recently in Nevada.

These specimens, which are described below, were secured by the writer's son, B. F. Howell, Jr., from the Tank Hill Limestone, a formation of Late Canadian or Chazyan† Ordovician age on the western slope of Battleship Mountain, in the Ely Springs Range, southeastern Nevada. They are beautifully preserved and appear to belong to the species *Receptaculites mammillaris*, which was described by Dr. C. D. Walcott from the Eureka district of Nevada many years ago, but of which only Dr. Walcott's single, rather unsatisfactory, figure has ever been published.

Dr. Walcott intended to publish a fuller description of *Receptaculites mammillaris*, with additional illustrations; but he never did so. The present paper will therefore supplement Dr. Walcott's original description, as he himself had hoped to do, and will make available to paleontologists additional figures of this species, which is one of the commoner members of the fauna of the Tank Hill Formation of the Ely Springs Range, in the Pioche district of southeastern Nevada.

Family Receptaculitidae Roemer
Receptaculites mammillaris Walcott
Pl. I, figs. 1–5; pl. II, figs. 1, 2.

Receptaculites mammillaris Walcott, U. S. Geological Survey, Monograph 8, 1884, pp. 65–66, pl. 11, fig. 11.

Receptaculites mammillaris Walcott, Winchell and Schuchert, Geology of Minnesota, vol. 3, pt. 1, 1895, p. 60.

Receptaculites mammillaris Walcott, Grabau and Shimer, North American Index Fossils, vol. 1, 1906, p. 19.

As shown in the figures, this species varies in form, some specimens being half as high as they are wide, while others are three times as wide as they are high. The walls vary in thickness from 20 mm. in small specimens to 30 mm. in large ones, and the aperture of the internal cavity varies in diameter from 10 mm. to 20 mm. As noted by Walcott, the rhomboidal plates of the outer surface of the fossil increase in size from the base to the upper edges of the "cup." The vertical tubes which extend from the outer surface to the plates

* For a full discussion of the Receptaculitidae see Hinde, J. G., Quarterly Journal of the Geological Society of London, vol. 40 (1884), pp. 795–849, pls. 36–37.

† Edwin Kirk (American Journal of Science, 5th series, vol. 28, 1934, pp. 454–455) states that, although most of the Tank Hill Formation is of Chazyan age, the lower part, in which these receptaculitids occur, is of Late Canadian age (*Didymograptus bifidis* Zone).

of the inner wall are also shorter in young specimens and in the lower parts of the bodies of adults that were formed during the earlier stages of growth.

Our specimens, which are now composed of finely crystalline calcite, are preserved in a dark gray, finely crystalline limestone, and have the same color as the rock which surrounds them. Other fossils of various kinds occur in the same beds, among them another species of receptaculitid, *Receptaculites ellipticus* Walcott, trilobites, brachiopods, and what is probably a species of the calcareous alga genus, *Girvanella*. The alga resembles in general form *Girvanella ocellata* (Seely),* which is found in the Chazyan beds of Vermont, New York, and Tennessee; but the condition of preservation of the Nevada specimens, which does not permit of the examination of the details of their internal structure, prevents their certain identification as that species.

Our specimens of *Receptaculites mammillaris* from Battleship Mountain, in the Ely Springs Range of Nevada, are plesiotypes, nos. 53408–53411, 53413, and 53414 in the paleontological collection of Princeton University. An additional specimen from the Ordovician of Nevada, whose exact horizon and locality are not known, but which was very probably collected from the Chazyan Pogonip Formation of the Eureka district, and which is plesiotype no. 5926 in the Princeton collection, is also figured, as it is a good example of the low broad form of the species.

Walcott, in his original description of *Receptaculites mammillaris*, stated that it resembled the common eastern North American Middle Ordovician Black River species which James Hall† had identified as the European species, *Receptaculites neptuni*, but which J. W. Salter‡ later proved to be a new form, which he named *Receptaculites occidentalis*. The two species do resemble each other in the smaller details of their structure, but seem to have differed in general shape and size, *R. occidentalis* having been apparently more saucer shaped and less cup shaped than *R. mammillaris*, as well as somewhat larger.

The Chazyan receptaculitids of the Ely Springs Range probably lived in rather shallow waters, for the Tank Hill Formation of southeastern Nevada is said to be composed in part of conglomeratic limestones, which must have been formed at shallow depths.§ The limestone in which they are now preserved was probably a soft, calcareous mud at the time when they were buried in it. The receptaculitids with the more cup-shaped bodies would seem to have lived with the lower parts of their bodies so far immersed in this mud that the mud held them in position and they could therefore retain the vertical attitude which was necessary for their existence, for no traces of well-developed means of attaching themselves to the ocean bottom have been observed in their fossils.

Perhaps the more cup-shaped receptaculitids began life as tiny bodies which would be buoyant enough to rest on the soft, calcareous mud without

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* Seely, H. M., Amer. Jour. Sci. Arts, 3rd ser., vol. 30, 1885, p. 357, figs. 1–3.

† Hall, J., Palaeontology of New York, vol. 1 (1847), p. 68, pl. 24, figs. 3 a–d.

‡ Salter, J. W., Canadian Organic Remains, Geological Survey of Canada, dec. 1 (1859), p. 45, pl. 10, figs. 1–7.

§ Westgate, L. G., and A. Knopf. U. S. Geological Survey Professional Paper 171 (1932), p. 14.

sinking into it, and then gradually settled partly into the mud as they grew larger and heavier and needed to be partly buried so that they would not fall over on their sides or be knocked over by waves. Those individuals whose bodies were longest and more vase shaped than cup shaped must have lived where the waves were ordinarily not very strong, for strong waves would probably have knocked them over, even if they were partly immersed in the mud. But the more cup-shaped and saucer-shaped individuals could have lived in shallower or more turbulent waters without being so easily turned over, although it is possible that they grew broader and less vase shaped or cup shaped as they became larger, just so that they would be less likely to sink so far into the soft mud as to become completely buried and thus smothered.

Because we do not know exactly how these peculiar organisms secured their food it is difficult for us to imagine how they appeared in life. We can, however, picture them to ourselves as having been abundant on the bottoms of some Ordovician and Silurian seas, for their fossils are often found in large numbers in the limestones which were deposited there. It is hoped that some fortunate collector of the future will find specimens which are so well preserved that we shall be able to determine with certainty the original chemical composition of their hard parts and the nature of their soft parts. When we have secured that knowledge we shall be better able to visualize their habits and true appearance when alive.

The other members of the fauna of the Tank Hill Limestone make up a typical Ordovician marine fauna. They include, in addition to *Receptaculites ellipticus* Walcott and the *Girvanella*, mentioned above, a sponge, *Zittelella clarae*, an unidentified species of *Tetradium*, a species of *Columnaria* which is close to *Columnaria simplissima* Okulitch* (originally described from the Chazyan Lenoir formation of Virginia), an unidentified bryozoan, twelve species of brachiopods—*Orthis swanensis* Ulrich and Cooper, *Orthis paucicostata* Ulrich and Cooper, *Orthis eucharis* Ulrich and Cooper, *Orthis michaelis* Clark, *Archaeorthis costellata* Ulrich and Cooper, *Archaeorthis elongata* Ulrich and Cooper, *Anomalorthis lonensis* (Walcott), *Tritoechia sinuata* Ulrich and Cooper, *Tritoechia alta* Ulrich and Cooper, *Hesperonomia fontinalis* (White), *Hesperonomia antelopensis* Ulrich and Cooper, and *Aporthophyla typa* Ulrich and Cooper—unidentified pelmatozoans, snails, and trilobites, and the ostracod, *Leperditia bivia* White. Most of the brachiopods are members of "Upper Pogonip" faunas of other parts of Nevada. Two of them, *Orthis swanensis* and *Orthis michaelis*, are species of the Swan Peak fauna of Utah.

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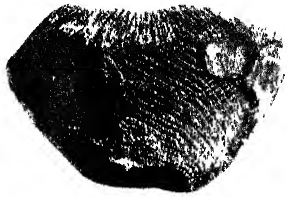
* The author is indebted to Professor E. C. Stumm, of Oberlin College, for the identification of this coral.



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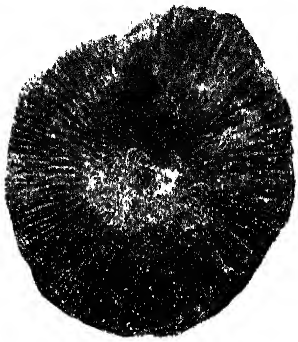

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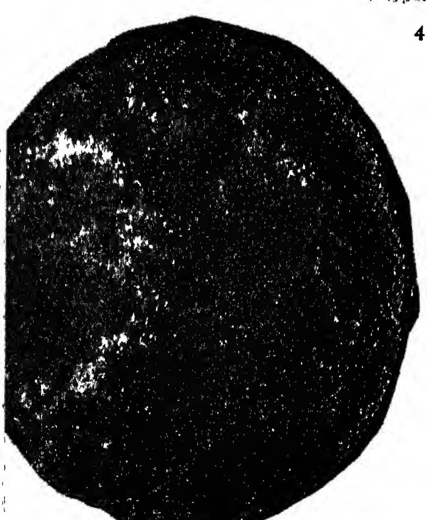

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Explanation of Plates

Plate I

Fig. 1: *Receptaculites mammillaris* Walcott. Side view. X1. Tank Hill Formation, Lower Ordovician, Battleship Mountain, Ely Springs Range, Nevada. No. 53413, Princeton Univ.

Fig. 2: The same, bottom view.

Fig. 3: The same, top view.

Fig. 4: *Receptaculites mammillaris* Walcott. Side view. X1. Probably Pogonip Formation, Lower Ordovician of Eureka district, Nevada. No. 5926, Princeton Univ.

Fig. 5: The same, bottom view.

Fig. 6: The same, top view.

Plate II

Fig. 1: *Receptaculites mammillaris* Walcott. XI. Tank Hill Formation, Lower Ordovician, Battleship Mountain, Ely Springs Range, Nevada. No. 53411, Princeton Univ.

Fig. 2: *Receptaculites mammillaris* Walcott, *Receptaculites ellipticus* Walcott and *Girvanella ocellata* (Seely) ? XI. Tank Hill Formation, Chazyan, Lower Ordovician, Battleship Mountain, Ely Springs Range, Nevada. No. 53410, Princeton Univ.

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BULLETIN

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INSECT ASSOCIATES OF CAKILE EDENTULA (BIGEL.) HOOK, THE AMERICAN SEA ROCKET

By JOHN G. HOPE

Curator, Wagner Free Institute of Science

Introduction

The observations upon which the following notes are founded were made during July, 1941, at Holiday Beach on Seven Mile Beach, N. J. This is one of the sea islands fringing the New Jersey coast. The area where collections were made lies between Peermont and Stone Harbor. These sea islands have been well described phytoecologically by Harshberger (Harshberger, 1900), and the area under consideration belongs to the Middle Beach of his classification.

The Habitat

The Middle Beach is determined by the presence of driftwood and extends from the barren Lower Beach to the foot of the dunes. The Succulent Zone (Middle Beach) of Harshberger is characterized by the Cakile-Ammodenia Society, Salsola Society, and Atriplex Society. The first only was found at Holiday Beach, and as no specimen of Ammodenia was seen, this may properly be shortened to Cakile Society. Isolated individuals of Euphorbia polygonifolia L. and one or two other species were found in the zone, but were so few as to be insignificant. The Cakile grows up to the foot of the dunes, which are covered with a growth of Marram Grass, Ammophila arenaria (L.) Link.

Cakile edentula (Cruciferae) is strongly succulent and well adapted to its rigorous existence. The plants are low in habit, and bushy-branched from the long-branching tap-root. The lower branches are often spreading, the central ones erect. The leaves are sinuate-dentate or lobed and very thick; flowers small, a faint purplish color appearing white, and the fruits jointed and indehiscent. The plant is very fleshy throughout. The density of the plants in the society was approximated by counting two quadrats of 100 sq. metres

each, selected at random. In quadrat No. 1 there were 152 plants, in quadrat No. 2, 803 plants. Thus the density varies considerably, but quadrat No. 2 is perhaps more characteristic of the society as a whole.

In the table below are given the physical factors measured at the time of each collection:

Collection No.	*Air T.–C.*	*Substratum T.–C.*	*Relative Humidity*	*Wind*	*Solar Radiation*
2	23.5°	27.5°	88.8%	S.-S. W. fresh	Clouds 75% bright
3	27.5°	30°	79.6%	W. fresh	Clouds 0% very bright
4	25.5°	36.2°	91.3%	S. moderate	Clouds 0% very bright
5	25.3°	29°	91.2%	S. E. moderate	Clouds 70% hazy and dull
6	20.4°	20.2°	92.6%	S. moderate	Dark 9 P.M.
7	25.4°	30°	91.3%	Still	Clouds 30% very bright

Substratum temperature indicates that recorded by the thermometer with the bulb just covered with sand and placed at the base of a plant. Relative humidity was determined with a sling psychrometer and the percentage of cloudiness was estimated.

Collections

An effort was made to collect in such a way that the relative abundance of species would be indicated. The cylinder method was tried with poor results. The area covered by the cylinder is small, but the most serious objection is that delicate flies and other insects are crushed and lost in the sand. The beating method was considered unsuitable, and the "Zeitfang" method was finally employed. With but one exception the collections were made over a period of one-half hour in the mid-afternoon of each day. Collection 6 was made from 9.15 to 9.45 P.M. During the half-hour period each plant was carefully examined and any insects on it or on the sand near it were taken by hand. Insects flying over the plants were taken with a small net. Collecting continued without pause for the half-hour period and approximately the same area was covered for each collection. The results are given in the following table:

Insects	2	3	4	5	6	7	Total
			Collection Number				
ORTHOPTERA:							
Trimerotropis maritimus Burm. (Seaside locust)	3	3	1	1	5	2	15
HEMIPTERA:							
Aphidae (Plant lice)			very numerous				
* Podisus maculiventris Say	..	..	..	..	..	1	1
LEPIDOPTERA:							
Pieris rapae L. (Cabbage worm)	larva	..	..	..	..	..	1
DIPTERA:							
Rhamphomyia candicans Loew. (Dancefly)	4	..	2	2	seen	..	8
Syrphus americanus Wied.	..	1	..	..	..	..	1
* Mesogramma marginata Say	..	1	..	..	..	..	1
* Laphystia 6-fasciata Say	..	..	..	..	4	..	4
* Mesogramma polita Say	..	..	..	..	..	1	1
Sarcophaga carnaria L. (Flesh fly)	..	..	..	..	..	2	2
Tabanus lineola Fab. (Green-headed fly)	seen	seen	2	..	..	..	2
Trypetidae—unidentified (CD4)			very numerous				
COLEOPTERA:							
* Cicindella lepida Dej.	1	..	..	..	..	..	1
Anisosticta seriata Melsh.	..	2	..	..	..	..	2
* Hippodamia convergens Guer.			very numerous				
* Coccinella 9-notata Hbst. (Lady-bug)	..	..	1	..	..	..	1
* Saprinus fraternus Say	..	..	1	..	..	..	1
Saprinus pennsylvanicus Payk.	..	..	..	..	..	1	1
* Ligyrus gibbosus De Geer	..	..	1	..	1	..	2
* Diabrotica 12-punctata Oliv.	..	..	..	1	..	..	1
* Monocrepidius vespertinus Fab.	..	..	..	1	..	..	1
Platynus punctiformis Say	..	..	..	..	..	1	1
Unidentified (CC5)	..	..	2	..	..	1	3
Unidentified (CC2)	1	..	..	..	..	..	1
Unidentified (CC7)	..	..	1	2	..	2	5
Unidentified larva (CC11)	..	..	..	2	seen	..	2
HYMENOPTERA:							
* Formicidae (Ants)			very numerous				
Tiphia inornata Say	2	..	..	3	..	..	5
* Mutillidae (Velvet ants)	1	..	2	..	..	1	4
* Microbembex monodonta Say	..	1	1	..	..	..	2
Unidentified (CH6)	..	..	1	..	..	..	1
Unidentified	..	1	..	..	..	..	1
ARACHNIDA:							
Spiders	2	..	2	..	..	..	4

* These species are also recorded from barren sandy areas, chiefly "blowholes," near Havana, Illinois. (Hart and Gleason, 1907.)

A few species were so numerous that the entire half-hour period could have been spent in collecting them. These have been marked "very numerous." Collection number 1 represents the abortive attempt to use the cylinder method. Therefore this collection is not comparable with the others and has been omitted from the tables.

Discussion

While the samples were relatively few and taken over a short period of time, they serve to show that there is a definite association of insects with Cakile edentula. In consideration of the rigors of a sea-beach environment, the variety of forms taken is surprisingly large. From the table above we note that there are represented in the collections six orders of insects, including thirty genera and thirty-two species. The species representing genera are extremely limited, a genus being represented by more than one species in two cases only. A table of orders may be arranged showing the number of genera represented as follows:

Coleoptera	13
Diptera	7
Hymenoptera	6
Hemiptera	2
Orthoptera	1
Lepidoptera	1

However, in many cases genera are represented merely by one or two individuals which might be stragglers, i.e., have no real connection with the Cakile community. For example, the Saprinids and Sarcophaga carnaria are associated with decaying matter, Tabanus is wide ranging, etc. A better picture is presented by considering the number of individuals taken. Some species were very numerous and taken under circumstances which leave no doubt about their intimate connection with the Cakile society. The aphids occurred on most of the plants examined and inflicted rather serious damage upon them, causing severe wilting of the tender tips of shoots and immature fruits. Hippodamia convergens was extremely numerous, and by reason of preying on the aphids favors Cakile. The Trypetid fly CD4 was very numerous, but the relationship of this fly to the society is not known. The Formicidae construct their nests beneath and around the roots of the plants. The Orthopteran Trimerotropis was represented in most cases by nymphs. While more abundant in the Ammophila Society of the dunes, they were not uncommon on the Middle Beach. This locust with Cicindella lepida is adapted in coloration for life on the sand. Cicindella is a carnivore and not peculiar to the Cakile society. The Syrphid flies and some of the Hymenoptera may play some part in the fertilization of the Cakile flowers, and Syrphid larvae are known to live in Aphid colonies, destroying these pests. The Lepidopteran larva, Pieris rapae, usually feeds on the cabbage, of which Cakile is a relative, though a distant one. It was also reported feeding on Cakile by Hamilton (Hamilton, 1885).

According to this author, the beetles, Saprinus pennsylvanicus and S. fraternus, are associated with human excrement, and Anisosticta seriata Melsh. is usually taken about the remains of dead animals. Ligyrus gibbosus DeGeer was taken by him at light in great numbers. He also reports Platynus punctiformis as plentiful, living under all kinds of debris and decaying grass.

From the one collection and several observations made at night no distinct nocturnal insect fauna could be distinguished. It is remarkable that the fly Laphystia 6-fasciata was taken only at night and was found in the sleeping

position on the leaves of Cakile. Trimerotropis maritimus was also taken at night at rest on Cakile.

A table summarizing the constancy of species in the collections follows:

Present in all collections	5 species
Present in five collections	0 species
Present in four collections	1 species
Present in three collections	3 species
Present in two collections	7 species
Present in one collection	17 species

Those species represented in all collections, i.e., the most constant are also the greatest in number of individuals per collection.

Summary

1. During July, 1941, a series of collections of insects was made from the Cakile Society at Holiday Beach, N. J. The "Zeitfang" method was used for quantitative approximations.

2. A surprisingly large number of genera and species was taken, but as some genera are represented by only one or two individuals, many of them are probably not in intimate association with the Cakile Society. A few species, represented by numerous individuals, are intimately associated with the Cakile Society.

3. No definite nocturnal insect association was found during the period covered by the observations. Although a fly, Laphystia 6-fasciata was taken only at night, it was always in the sleeping position.

4. Fourteen of the species taken have also been reported from barren, sandy areas near Havana, Illinois.

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A SYNOPSIS OF THREE LECTURES

FROM NATURE THROUGH THE TEST TUBE TO TEXTILES AND PLASTICS

(Delivered under The Richard B. Westbrook Free Lectureship, 1942)

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LECTURE I

TEXTILE FIBERS—NATURAL FIBERS WHICH HAVE SERVED MANKIND THROUGH THE CENTURIES

"A bit of cloth—whether it be woolen or cotton, linen or silk—is one of the most interesting evidences of man's climb from days of savagery to twentieth century civilization." Thus speaks Perry Walton in the opening sentence of his book, "The Story of Textiles," and I think that we can accept this without challenge.

Since the earliest historical records show that fabrics were already well known at the dawn of history, we should be permitted a certain amount of speculation as to what had gone before. It seems a safe assumption that when prehistoric man first sought to clothe himself he turned first to the skins of the animals he had killed for food. Next, perhaps, he tried to utilize the grasses and leaves from the vegetable kingdom. From here it is a logical step to the braiding of grasses or similar materials into a crude fabric mat.

Authorities who have studied the question do not agree as to which fiber is the oldest, but it is sufficient for our purpose to say that when the veil is first lifted four fibers are well known—cotton, linen, silk, and wool—and these very same fibers still are the basis of our fabrics today. All of these fibers were probably in regular use for thousands of years before the beginning of the Christian era.

Cotton

From four-fifths to nine-tenths of the world's raiment supply, including important accessories, such as thread, tape, binding, belting and trimming, is made from cotton fibers. In the Valley of the Indus, cotton was in general use when the earliest records were made, and from India the cultivation of cotton spread to Persia and to Egypt, stimulated by the stories brought back by invaders and travelers.

It is not possible to say how cotton cultivation came to America, but Columbus found both cotton fiber and cotton cloth here; today the United States leads the world in cotton production, for which our Southern States provide the ideal environment. Here cotton is a soft-stemmed annual shrub growing from two feet to six feet high.

The method of harvesting the cotton crop has had a great influence on its utilization. At first the cotton was picked and the fiber separated from the seeds by hand. With the invention of the cotton gin by Eli Whitney in 1793 the latter process was revolutionized and impetus given to the whole cotton industry. In passing through the gin, the longer fibers are separated from the seeds and pressed into a bat ready for baling. The seeds have clinging to them a short fuzz which is removed by a second ginning process. This short fiber makes up the cotton linters which provide cellulose for nitrocellulose and rayon. The seeds are used in making cottonseed oil, an important article of commerce.

The cotton fiber is unique in that it appears to consist of a single cell. On microscopic examination, it shows a flat and twisted structure resembling somewhat an empty and twisted fire hose. This characteristic is of great economic importance because the natural twist facilitates the spinning of cotton fibers into thread or yarn.

Cotton is the one fiber that will withstand much rough handling, high temperatures, and boiling water. These characteristics, coupled with the comparatively low cost of cotton, contribute largely to its almost universal use in fabrics.

Linen

The mention of the word linen conjures up an image of a material of quality. "Arrayed in fine linen" is a phrase which has been applied to persons when clothed in the finest of garments. The linen fiber comes from the flax plant—in fact, the term flax is also often applied to the fiber.

Flax is a tender annual like cotton. It grows from 1 to 3 feet high, bearing small narrow leaves and numerous bright blue flowers ½ inch across in a leafy cluster. The plant is a native of Western Asia and from there it has spread to the rest of the world, but it grows best in the temperate zone.

Unlike the cotton process, where hand operations end with the picking of the cotton, the production of the flax fiber is a hard, monotonous task. The flax must be harvested by pulling the plants up by the roots, knocking off the dirt, and spreading the flax out in parallel rows to dry. The dry plants are then drawn through a "rippler" which removes the seeds, small leaves and tops.

The flax fiber in the stem of the plant is securely protected on the outside by a thin layer of woody tissue which must be removed by decomposition or retting. To accomplish this the flax is immersed in water or exposed to the weather. The flax is again dried, and passed through a machine to break the rotted tissue into small fragments. After this it is subjected to roughing or scutching, a series of processes designed to remove all of the woody coating. The fibers are then drawn over a series of hackles with sharp pins or teeth which subdivide and straighten the fibers and also take out short, broken and tangled ones.

The linen fiber is the strongest of our fine vegetable fibers, but linen is more easily injured by high temperatures and hot water than is cotten, therefore it should not be boiled and care should be used in ironing.

Silk

If cotton is called the fiber of utility and linen the fiber of quality, then a comparable term for silk would be the fiber of luxury. Silk was one of the items of the fabulous riches of the East which spurred on the traders and explorers to adventures over unknown seas in search of new trade routes. It is first referred to in Chinese literature as dating from as far back as 2500 B. C.

In contrast to the two fibers already discussed, silk can be considered as of animal rather than vegetable origin. It is produced by the silkworm, which spins the fiber around itself as a cocoon. The silk moth lays eggs from which the caterpillar hatches. The seeds are laid on cards and are kept in a cold place to prevent their hatching until needed.

The tiny worms which hatch from these eggs are carefully tended. They are fed chopped mulberry leaves, one ton of leaves being required as nourishment for worms which will yield 12 pounds of silk properly reeled. After feeding for a month, the silkworm seeks a place to spin, for which purpose twigs are supplied. The silk thread, which is contained in the worm as liquid silk, is extruded from the spinneret as two separate filaments glued together with silk gum. From these the silkworm, after forming a nest, builds his cocoon by throwing the filament in a series of figure 8's up and down his body. Three days are required to form the cocoon, and in that time 3,000 to 4,000 yards of a single fiber have been spun.

The process of reeling off the silk fiber from the cocoon is a delicate one and is carried out with great care. The skeins of raw silk, arriving at the mill, are rewound, stretched, doubled and twisted to form the kind of yarn desired.

Silk is the longest, lightest weight, strongest for equal cross-section and finest of all natural textile fibers.

Wool

Wool comes from the hair of sheep and is identified by its name as having this origin. The hair of other animals is designated by the name of the animal, as, for example, rabbit hair, horse hair, etc.

It is probable that at first the whole skins of animals were used for clothing, but by 3000 B. C. real woolen clothing had made its appearance.

The first step in preparing wool for the market is the shearing of the sheep. Next the fleece is baled in huge burlap sacks and shipped in this form.

The wool is sorted for quality, cleaned and carded, the latter process being performed by cylinders covered with fine wire bristles. From this point on the procedure is different, depending on whether the fiber is to be used for woolen or for worsted goods. In the worsted yarn the fibers are approximately parallel to each other producing a smooth, lustrous yarn, while woolen yarn has a more heterogeneous arrangement of fibers with many free ends projecting.

The wool fiber differs from the others in that the outer layer of the individual fiber consists of flattened, scale-like cells of varying shapes and sizes. The greatest disadvantage of wool is the care necessary in laundering to prevent shrinkage and hardening of the fabric. Wool is sensitive to alkalies but not affected by dilute acids.

These then are the fibers of antiquity; they are also in a very real sense the fibers of today. There are other natural fibers which can only be mentioned: ramie, a reed fiber from the Orient, would be useful if an easy process could be found to separate it; jute and hemp, largely imported, are used for bags and coarse fabrics; asbestos, a mineral fiber, useful for insulating and fireproof fabric. There are several animal fibers used in special fabrics and these fibers frequently carry the same name as the animal from which they come. Among these are mohair (Angora goat), Alpaca, Vicuna, Cashmere, and camel's hair.

Each of the fibers described has its own characteristics which have guided its application in the fabrics of commerce. Availability and cost of production determine in large measure the volume consumption of a fiber. Cotton holds its position at the top of the list because, in addition to having satisfactory properties, its cost is low and it is readily available. Silk, because of its luxurious texture and soft, deep luster, commands a higher price.

The shortcomings of these fibers or their high cost have been a challenge to research to produce synthetic fibers. The next lecture will describe the entrance of rayon and certain newer fibers into the textile field.

LECTURE II

Textile Fibers—Synthetic Fibers already Commercially Recognized which Promise New Fabrics for the Future

In the previous lecture the natural textile fibers, cotton, linen, silk and wool, were discussed and it was shown that they fit into a time-table measured in thousands of years. On this basis it is only within a very short time (about 100 years) that man has succeeded in developing a fiber which could establish itself on a competitive basis with these natural fibers. During this time many minds had toyed with the idea of duplicating the processes or the results of the silkworm. There were many characteristics of silk which made it a fiber that man was anxious to duplicate. The fact that silk is the only continuous filament among natural textile fibers was important, but probably the most

difficult characteristic to attain in a synthetic fiber was the combination of high strength and elasticity, which characterizes the silk fiber. This was the goal which challenged the inventive genius of man.

The foundation for the production of the first synthetic fiber was laid in the year 1664, when Dr. Robert Hooke, an English scientist, wrote that he thought it possible to make an "artificial glutinous composition" resembling the silkworm "excrement." In 1845 Schoenbein also contributed to progress along these lines by his epochal discovery of a new material—cellulose nitrate—capable of being expanded into a whole family of other new and yet undreamed-of materials. At about this time a mechanical process was invented for producing woodpulp and also a machine was invented for drawing out substances through fine holes into filaments or threads. Since none of the substances then available was satisfactory for successful fiber production, the search for a satisfactory filament became intense. Although the first patent on an artificial fiber made by hand dipping was taken out by Audemars in 1855, this remained a laboratory curiosity, since it did not occur to him to force his solution through some fine hole. After the invention of the electric lamp, in 1883 Joseph Swan was awarded a patent on a nitrocellulose filament for use in electric lighting, but there was still no commercial textile fiber.

In 1884 the "Father of the Rayon Industry," Count Hilaire de Chardonnet, produced the first synthetic fiber, using nitrocellulose made from the wood of the mulberry tree. Research on the production of a synthetic textile fiber did not end here, however, but still other methods for its manufacture were developed, including the cuprammonium process, viscose process and cellulose acetate process, and all of these have contributed to the final development of the synthetic fiber, rayon, as we know it today.

Viscose Rayon

Cellulose pulp from cotton or wood is used as raw material for the manufacture of viscose rayon. The pulp in the form of sheets is soaked in 18% caustic soda solution for 30 to 90 minutes. The excess caustic liquor is pressed out and the alkali cellulose, as it is now called, is shredded to a fluffy condition. After aging, the alkali cellulose is reacted with carbon disulfide for several hours and is changed to a bright orange color. It is now called cellulose xanthate and is mixed with dilute caustic soda. This orange colored solution is called viscose, and is what gives the name to the process. After this solution "ripens" it is ready for the spinning operation.

Acetate Rayon

The manufacture of acetate rayon is sufficiently different from that of viscose rayon to warrant spending a little time describing it. In this process cellulose pulp from cotton linters is steeped in acetic acid, allowed to age, then treated with acetic anhydride, which might be considered to be dehydrated acetic acid. In this step the cellulose is converted to cellulose acetate which dissolves, forming a colorless liquid. The cellulose acetate is again aged, and then precipitated by running the solution into water. Excess acid is washed from the white solid acetate. The cellulose acetate is now dissolved in acetone to form the spinning solution.

Other Rayons

No rayon has been manufactured in the United States by the nitrocellulose process since 1934. In 1941 less than 5% of the production was from the cuprammonium process.

Nylon

As a result of fundamental chemical research started in 1928 by Dr. W. H. Carothers and collaborators for E. I. du Pont de Nemours & Company, announcement was made in 1938 of the new nylon fiber, which was the first really synthetic fiber. Nylon is a generic name coined by the Du Pont Company to describe a group of new synthetic, protein-like materials—polyamides —somewhat similar in chemical composition to silk and wool, yet having a chemical structure not found in nature.

The basic raw materials used in the manufacture of nylon are carbon, hydrogen and oxygen (from coal and water) and nitrogen (from the air). These chemical elements are combined in suitable reactions to form diamines and dibasic acids. The combination of diamine with dibasic acid yields nylon salt, which is polymerized, or induced to form large molecules. The properties of the finished product can be varied almost at will by the proper selection of amine and acid combinations.

Nylon, of course, has been widely accepted in hosiery, but it has also been used in a large number of other fabrics. By the use of suitable openings nylon monofilament of many sizes can be produced. These are used in brush bristles, fishing lines, surgical sutures, and tennis racquet strings.

Vinyon

About a year after nylon was announced, another new synthetic fiber, "Vinyon," was reported. This is also based on abundant American raw materials but its chemical structure is quite different from nylon. The class of vinyl polymer resins has been known for some time and has application in the field of plastics, which is to be covered in the following lecture.

Two members of this group, vinyl chloride and vinyl acetate, when polymerized separately, have characteristic properties of their own which, however, are unsuitable for fibers. But when vinyl chloride and vinyl acetate are polymerized simultaneously in the presence of each other under suitable conditions, a copolymer is obtained which is satisfactory for spinning into a fiber.

Vinyon has been used in an important group of industrial fabrics, including filter cloth, pressed felts, sewing threads and twines of various construction. Its acid and alkali resistance as well as water resistance fits it for special applications.

Protein Fibers

Possible sources for proteins are milk, soy bean, corn, cottonseed, peanuts, maize, wheat, and slaughterhouse refuse. Protein fibers from milk and soy bean have reached the greatest importance, and their manufacture will be considered.

Casein for fiber production is precipitated from sweet skim milk by means of sulfuric acid. The precipitate, after being washed, is redissolved and reprecipitated to remove mineral salts. The casein is then dissolved in alkali and certain agents are added to strengthen the fiber. After deaëration and aging the casein solution is extruded through a spinneret into an acid-coagulating bath.

To obtain protein fiber from soy beans, the beans are crushed and the oil is extracted by means of hexane or other organic solvent. The soy-bean meal remaining after the extraction is further extracted with sodium sulfide and reprecipitated with acid. The protein is washed and dried and then is processed in a similar manner to that for casein.

Glass

The manufacture of glass fiber is quite simple compared with the fibers which have been discussed. The molten glass is extruded through orifices with precious metal bushings, and the continuous filament is drawn mechanically by a drum, twisted and spooled. These fibers are used in insulation, filters, ignition cables, tablecloths, draperies, bedspreads.

These are the fibers of major importance today. There are others, but they cannot be presented adequately in this lecture.

Rayon is well established in the textile field, and production will undoubtedly reach to greater heights in the future. The development of other fibers, such as nylon, has been interfered with by the wartime conditions. All available plant capacities are being utilized for defense needs but it seems a safe prediction for the years ahead that synthetic fibers will make possible fabrics of utility and beauty in many new applications. But, as so often happens in developments such as these, there should be plenty of room for the natural fibers upon which we have depended for so long for comfort and neat and attractive appearance.

LECTURE III

Plastics Provide New Materials of Utility and Beauty

The inclusion of synthetic textile fibers and plastics in the same course of lectures is a logical procedure because the same basic material may be used in either application. Cellulose nitrate was the base of the first rayon and is widely used in plastics. Cellulose acetate, which is increasing in rayon application, is also used in molding powders and photographic film. The term "plastic" comes from the fact that a material while in plastic condition is shaped to a certain design but the final product is usually fixed in form.

Plastics began as subsidiary materials to the basic materials already in use and, having first substituted for metal and wood in many applications, they have now established themselves in their own right as materials of construction.

The plastic art is old because in the dim and distant past the potter

modeled his clay, made workable with water, into vessels and baked them in the sun. Color was added later with artificial firing, and still later glazing to avoid porosity. Glass also was known in these early days and was fabricated into quaint and beautiful vessels.

"Celluloid," cellulose nitrate, was the first modern synthetic plastic; bituminous materials and shellac from natural sources being used in battery jars and phonograph records respectively. About 1900, Galalith casein plastics were introduced and illustrate another link with the fibers. The event which more than anything elese stimulated modern activity in plastics was the introduction in 1909 of Bakelite, phenol-formaldehyde plastics. To improve on Bakelite in the matter of color the urea-formaldehyde and amine resins were developed.

Polyvinyl esters and acrylic resins have come out more recently and are finding ready acceptance.

Three methods for the hot forming of plastics are used; namely, compression, injection and extrusion through dies.

In compression molding, preformed, powdered or granular material is introduced directly into the open mold cavity and the mold, in closing simultaneously, applies heat and pressure to the material and causes it to flow and fill every part of the cavity. The material remains in the mold until cured by heat or set by cooling, as the case may be. Thermosetting materials are molded by compression because they harden or cure quickly on heating and cannot be held in a plastic state for long. Because for thermoplastic materials the mold has to be heated and cooled in each cycle, the procedure is inefficient and time consuming.

In the injection molding process, the plastics material is melted separately and forced into the cool, closed mold where it hardens. Ordinarily, materials for injection molding are limited to thermoplastic materials which can be held at molding temperature sufficiently long to complete the process.

In the extrusion process, plastic material in the form of powder, granulations or continuous ribbon is fed into the machine, carried by a screw through a heated cylinder, extruded through a die and picked up by a take-off device with precautions to avoid distortion.

Plastics can also be cast and then machined to the desired size and shape. Many improvements have been made in the process of manufacture so that larger articles can be made, and the time required has been greatly reduced.

In addition to molded products, plastics contribute to the manufacture of laminated products, in which fibrous sheets, such as paper, woven cloth, etc., are impregnated with a heat-reactive resin, as, for example, phenol-formaldehyde, and then the built-up layers are subjected to heat and pressure, forming a hard, tough, homogeneous material. The use of the plastic resins for adhesives in the manufacture of plywood is a closely related application.

Of the cellulose plastics, cellulose nitrate plasticized with camphor and called "Celluloid" was introduced by Hyatt in 1869. Used as a substitute for ivory, its applications broadened to include toilet articles, toys and novelties and, most important of all, photographic film. The introduction of cellulose acetate overcame the serious objection to the nitrate due to its

flammability. Since 1930 cellulose acetate has been widely used in molding materials. More recently cellulose acetate-butyrate gives improved water resistance. Ethyl cellulose is the newest member of the family with toughness at low temperature.

Phenol-formaldehyde resins were announced by Dr. Leo Baekeland in 1909, and from this time on the plastics industry has developed rapidly. In general they belong to the thermosetting (heat-hardening) class, although thermoplastic (heat softening) types can be made. Other phenols and aldehydes are combined to give special properties. These resins can be molded or cast and the latter form is characterized by machinability, high tensile and impact strength and rigidity.

To give the lighter colors, cream, ivory and pastel colors, the amine resins were developed, of which urea-formaldehyde is an example. Melamine is the newest amine to be used. These resins are characterized as odorless and tasteless, rigid, thermosetting, very light in weight and giving unlimited translucent or opaque colors. One important application has been Beetleware for table use.

Characterized by superior transparency, the acrylic resins, under the names "Lucite," "Crystallite," and "Plexiglas," have established themselves in the plastics field in recent years. They have been used to produce ornamental designs and novelty effects because of their property of edge lighting. More practical is their use in airplane construction and instrument panels for automobiles and airplanes. These plastics can be molded, cast and machined and take a high polish.

The vinyl resins include polyvinyl acetate and polyvinyl chloride and the copolymer of these two under the name of Vinylites. These resins are characterized as being odorless, tasteless, non-toxic, non-flammable, tough, with excellent water and chemical resistance. Polyvinyl butyral, which is an acetal, is used for the interlayer in high test safety glass.

Polystyrene is a resin with excellent electrical resistance, and vinylidene chloride promises excellent molding properties.

Plastics in Defense and in the Future

Early plastics compositions were designed to meet certain special applications and then developed as substitutes for materials which were scarce and expensive. Finally, when strength was combined with other desirable qualities and to these was added beauty of color and design, plastics had arrived and their own unique position as a construction material was established. In the defense program now expanded to a war program, plastics were depended upon to make up for the shortage of metals and they responded in many applications. However, demand exceeded early estimates and before long plastics themselves were on priority lists.

As an engineering material then plastics are playing an important role in the industrial mobilization for war. The airplane is a typical example. In gun turrets and cockpit enclosures, in laminated wood and coated fabrics, and at many other points plastics contribute to the airplane structure.

Of the future it is necessary to say but little. As in many other cases, the steady onward progress of the plastics industry has been interrupted by the war. Demand for many normal applications is piling up due to shortages and will have to be met. Larger articles and new and more attractive designs can be expected. Plastics are a necessity.

THE WAGNER FREE INSTITUTE OF SCIENCE

BULLETIN

of the

WAGNER FREE INSTITUTE OF SCIENCE

PUBLISHED BY THE INSTITUTE

SYDNEY L. WRIGHT, *Editor*

Vol. 17 No. 3	Quarterly AUGUST, 1942	$1.00 per year Single numbers, 25 cents

WAGNER FREE INSTITUTE OF SCIENCE

HISTORY

The Wagner Free Institute of Science was founded in 1847 by William Wagner, a citizen of Philadelphia.

In his early life William Wagner became associated with Stephen Girard in the extension of Girard's mercantile business. While in Girard's employ he had the opportunity to visit foreign countries, and being interested in scientific pursuits, he made a study of scientific institutions abroad and collected natural history specimens which afterward formed the nucleus for the collections in the museum of the Institute.

The Institute itself had its inception in a series of free lectures delivered by Professor Wagner in his home. These lectures, begun in 1847, were continued until 1855, when the Institute was incorporated by act of legislature.

A large measure of credit is due Mrs. Louisa Binney Wagner, Professor Wagner's wife, for sympathy, understanding and active coöperation in the early days of the founding of the Institute.

In 1855 a faculty was appointed and the work was continued in a new location at 13th and Spring Garden Streets, the City of Philadelphia giving permission for the use of Commissioners' Hall. Some years later Professor Wagner decided to erect a building on the present site at Seventeenth Street and Montgomery Avenue. This building was completed in 1865 and occupied immediately.

William Wagner died in 1885 and the management of the Institute was transferred to a Board of Trustees.

In 1901 a wing was added to the building for the use of a branch of the Free Library of Philadelphia.

INSTRUCTION

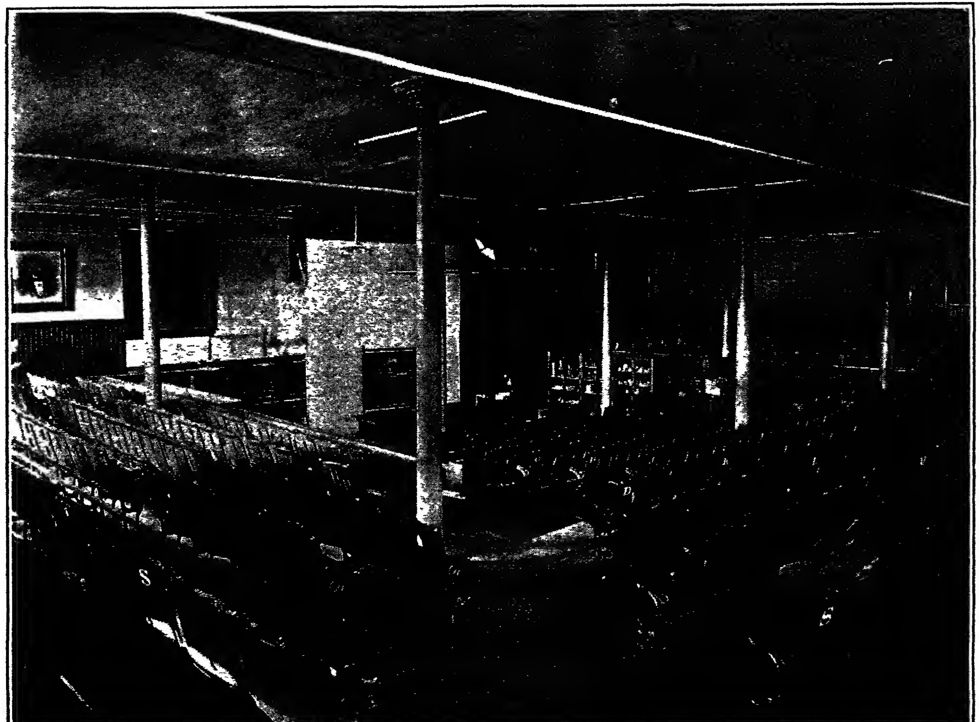
Lectures and Class Work

Instruction at the Wagner Free Institute of Science is conducted by means of lectures supplemented by class work. There are no tuition fees.

Persons may attend lectures without registering for the classes if they so desire. Those registering for the classes are required to hand in a weekly paper and are admitted to an examination at the end of the term. Those persons successfully passing the examination are awarded certificates for the year's work.

There are seven courses of scientific lectures covering a period of fourteen weeks each for four years. On the successful completion of four years' work a Full Term Certificate is awarded.

The closing of each lecture season is marked by Commencement Exercises.



Auditorium

MUSEUM

Museum

The Institute maintains a natural history museum containing more than 21,000 specimens illustrating the various branches of natural science.

The collections are arranged especially for study. The museum is open to visitors on Wednesday and Saturday afternoons from 2 P.M. until 5 P.M., except legal holidays.

On each Monday evening at 7, from September to May, a "Museum Talk" is delivered in the museum, the speaker using the specimens in the museum to illustrate the lecture.

Teachers and students desiring to use the museum for special studies will be admitted upon application at the office.

Libraries

The Reference Library of the Institute contains over 25,000 bound volumes and approximately 150,000 pamphlets on scientific subjects, classified and arranged for ready reference. There are also many foreign and domestic periodicals on file. The library is open to the public as well as to students from 10 A.M. to 9 P.M., Monday through Friday. Saturday, 10 A.M. to 5 P.M.

The Free Library of Philadelphia maintains a branch library in the building, known as the Wagner Institute Branch, from which books may be taken out under the rules of the Free Library.

Publications

The publications of the Institute consist of three series:

Transactions: begun in 1885 and discontinued in 1927.

Publications: succeeding the Transactions. These Publications are issued at irregular intervals.

Bulletin: issued quarterly.

SPECIAL LECTURES

Westbrook Free Lectureship

The Westbrook Free Lectureship is supported by the income from an endowment provided by Dr. Richard Brodhead Westbrook and his wife, Dr. Henrietta Payne Westbrook. The lectureship was established in 1912 and provides for one course of lectures each year. These lectures cover a wide range of topics and a list of those so far given may be found on page 35.

Fannie Frank Leffmann Memorial Lectureship

The income of a fund given by Dr. Henry Leffmann is applied to occasional special lectures under the Memorial Lectureship. These lectures are popular in character.

The *Philadelphia Natural History Society* is affiliated with the Institute and holds meetings on the third Thursday of each month from October to May.

RESEARCH

The Institute has carried on research work since 1885 in various departments of science. Results of research have been published from time to time in the Transactions, Publications and Bulletin.

The Institute is also the recipient of the income from two funds established by Dr. Henry Leffmann. This income is devoted to research in chemistry.

CERTIFICATES AWARDED AT CLOSING EXERCISES, MAY 20, 1942

FULL TERM CERTIFICATES

BOTANY

Anthony Albrecht
John C. R. Hofferbert
Caroline Reed
George F. Stauffer
William M. Thompson, Jr.
Agnes R. Zimmer

ORGANIC CHEMISTRY

Margaret H. Shipley

ENGINEERING

Lorenzo V. Blackston
Paul A. Fisher
George H. Shandle

***ZOOLOGY**

Gertrude A. Vieweger

GEOLOGY

Albert C. Schwabeland

PHYSICS

Adolph W. Awot

1941-42 CERTIFICATES AWARDED

BOTANY 3

Anthony Albrecht
Joseph M. Devlin
Frederick J. Duke
Agnes McFarland
Helen Ramsay
Caroline Reed
George F. Stauffer
William M. Thompson, Jr.
Robert W. Tuckey
Gertrude A. Vieweger
Agnes R. Zimmer

INORGANIC CHEMISTRY 1

Adolph W. Awot
James A. Bradway
Herman Donald
Violette L. Edwards
Paul A. Lockrey
Herman C. Mankin
Elizabeth M. McNichol
Joseph A. N. Meuser
Rudolph P. Meuser
Chester E. Myers
John P. Roarty
Norman A. Schoenhut

ORGANIC CHEMISTRY 1

Adolph W. Awot
Stephen W. Bartha
Randall Bernstein
James A. Bradway
Harold H. Brehouse
Herbert Fleu
Frances L. Getzman
William E. Good
Renate R. Hirsch
William J. Kiersznowski
Betty K. Kirk
John R. Landis
Herman C. Mankin
Elizabeth M. McNichol
Clarence Mosby
David H. Reighter
John P. Roarty
Margaret H. Shipley
Catherine F. Tucker
Richard Walters
Pauline F. Wright

ENGINEERING 3

Lorenzo V. Blackston
William H. Brown
Charles E. Clark
William H. Conley
Paul A. Fisher
William Heck
Earle W. Maier
Albert F. Ockenlaender
William A. Reese
Samuel Shober
Thom A. Street
George H. Shandle
Werner H. Schuele
William J. Schuele
Harry D. Smith
Homer J. Stineman

ZOOLOGY 2

Joseph M. Devlin
Agnes McFarland
Gertrude A. Vieweger

GEOLOGY 3

William H. Conley
Joseph M. Devlin
Helen Gabell
Amanda M. Kessler
William J. Kiersznoswki
Frank H. Moore, Jr.
Helen Ramsay
M. Dorothy Reed
Albert C. Schwabeland
Helen Shoemaker
Clarence Strohm
Charles S. Thompson

PHYSICS 4

Adolph W. Awot
James H. Bradway
William J. KierszNowski
Joseph A. N. Meuser
Albert F. Ockenlaender
Arthur G. Paul
Albert H. Petri
Edith H. Reeder
Thom A. Street

FACULTY

JOHN WAGNER

B.S. in C.E. 1913, University of Pennsylvania.
C.E. 1920, University of Pennsylvania.
1913–1916, Draftsman, Phoenix Bridge Company.
1916–1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921–1926, Assistant Supervisor Track, Reading Company.
1926–1928, Supervisor Track, Reading Company.
1928–1936, Industrial Agent, Reading Company.
1936 to date, Assistant General Freight Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date.

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899–1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906–1915.
Head of Science Department, Germantown High School, 1915–1923.
Principal, Roxborough High School, 1923–1924.
Principal, Germantown High School, 1924 to date.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906–1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:

"Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
"Ether Waves and the Messages They Bring," Transactions of the Wagner Free Institute of Science.
"The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900–1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901–1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916–1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921–1937.
Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.
Dean of the Faculty.
Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Sc.D. (Hon.), Bucknell, 1934.
Editor, American Journal of Pharmacy, 1921–1941.
Dean of Pharmacy, Philadelphia College of Pharmacy and Science, 1938–1940.

President, Philadelphia College of Pharmacy and Science.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Fellow of the Royal Society of Arts, London, Eng.
Member American Chemical Society.
Member American Pharmaceutical Association.
Member Penna. State Board of Health.
Publications:

"Recent Remedies," 1926 (revised 1928). International Publications, N. Y.
"Popular Science Lectures," 14 volumes (Editor). Phila. College of Pharmacy and Science, Phila.
U. S. Dispensatory (Collab. Editor), Lippincott, Phila.
Formula Book, A. Ph.A. (Editor), Lippincott, Phila.
A Science Miscellany, International Printing Company, Phila.
Contributor to current chemical, pharmaceutical and medical literature.

GEORGE BRINGHURST KAISER

Educated in private schools.
Graduate, Franklin School.
After graduation spent several years in intensive botanical study and field work in northeastern United States.
Secretary of the Botanical Society of Pennsylvania for seven years and leader of its field trips.
Professor of Botany, Wagner Free Institute of Science, 1927 to date.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology and Stratigraphy in Princeton University.
Lecturer on Paleontology and Geology, University of Pennsylvania.
Acting Curator, Department of Paleontology, Academy of Natural Sciences of Philadelphia.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Secretary of the International Paleontological Union.
Editor of the section of General Paleozoology of *Biological Abstracts*.
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, Colorado School of Mines, as a consulting paleontologist and research associate.

REGULAR LECTURES, SESSION OF 1942–1943

BOTANY 4

PROFESSOR KAISER

Physiology and Ecology

Lectures begin at 8 P. M.

1. Monday, September 14.
   How plants get their food from the necessary elements. The physics and chemistry of plant life. Cardinal points of growth.

2. Monday, September 21.
   How plants get carbon from the air. The necessity of leaf green in maintaining life upon the earth. The story of starch and its derivatives and of enzymes and their uses.

3. Monday, September 28.
   How plants get their nitrogen. How parasites, saprophytes and symbionts live. The helpful nitro-bacteria. The story of flesh-eating plants.

4. Monday, October 5.
   How plants breathe. Respiration contrasted with photosynthesis. How breathing in plants produces heat and light. Details of growth and development and the great age of trees.

Monday, October 12. No lecture.

5. Monday, October 19.
   How plants move from internal causes. Movements of vital fluid within walled cells and of diatoms and desmids. How floral clocks and calendars may be made.

6. Monday, October 26.
   How plants move from external causes. The stimuli of light, gravity and other forces that influence plants. The sleep of plants.

7. Monday, November 2.
   How plants increase and multiply. Vegetative and sexual reproduction. How pollen is borne by wind, insects, birds, snails, bats and water. How seeds are scattered to perpetuate the species.

8. Monday, November 9.
   How plants are distributed in relation to their surroundings. The zones of the earth and their vegetation. The part that water plays in determining floras. How plants succeed each other in geologic time.

9. Monday, November 16.
   How plants are distributed in North America. Plants of the coastal plain, sand dune and pine barren. The gulf states, lake shore and stream valley, prairie, forest, grassland and desert. The Pacific Coast.

10. Monday, November 23.
    How plants are distributed in Europe and Asia. The British Isles, Mediterranean region, China, the Himalayas and Japan, Russia, The Atlantic Islands.

11. Monday, November 30.
    How plants are distributed in the tropics of the Old World. The heart of Africa and continental Asia, "the cradle of the human race." Notable plants and delicious fruits of Malaya and the South Sea Islands.

12. Monday, December 7.

    How plants are distributed in the tropics of the New World. Characteristic species of Mexico, Central America, the West Indies, Trinidad and the wilds of South America. The virgin forest of Brazil.

13. Monday, December 14.

    How plants are distributed in South Africa, Australia, New Zealand, and South America. The region of Cape Horn. Gondwana Land of ancient geologic time.

14. Monday, December 21.

    How man has influenced the distribution of plants and the course of evolution. His destructive and constructive forces. Brief considerations of plant breeding, natural selection, mutation, heredity and hybridization. Recapitulation.

Field Trip

The class in Botany will be conducted on a field trip under the leadership of Professor Kaiser. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

INORGANIC CHEMISTRY 2

PROFESSOR HORN

Descriptive Chemistry

Lectures begin at 7.45 P. M.*

1. Tuesday, September 15.

   The Oxides and Acids of Nitrogen. Acid anhydrides. Nitric acid and its solvent power. Nitration and esterification. Explosives. Nitrous acid. Hyponitrous acid. Cyanides, cyanates. Halides of nitrogen. Hydrides of nitrogen. Hydroxyl amine.

2. Tuesday, September 22.

   Chemical Action and Chemical Equilibrium. Velocity of reactions. Effects of concentration, temperature, and catalysts upon velocity. Effect of promotors upon catalysts. Effects of concentration, temperature, and catalysts upon equilibrium. LeChatelier's Principle. Applications.

3. Tuesday, September 29.

   The Noble Gases. Ratio of their specific heats. Group Zero and the Periodic Table. Compounds of elements with zero valence. Helium: Atmospheric and terrestrial. Deep sea diving. Lamps. Neon: Lights. Argon: Discovery. Tungar rectifier. Krypton, Xenon, Niton: Characteristics.

4. Tuesday, October 6.

   The Oxides and Acids of Phosphorus. Allotropic forms. Its several valences. Phosphoric and phosphorous oxides. Three classes of ortho-phosphates. Super Phosphate fertilizer. Pyrophosphates. Metaphosphates: polymerization. Phosphonium compounds. Radio-phosphorus as a tracer. Matches.

5. Tuesday, October 13.

   Arsenic, Antimony and Bismuth. Non-metals, metalloids, and metals. Halides, sulphides and oxygen salts. Interesting alloys. White arsenic. Tartar emetic, sub-nitrate of bismuth. Insecticides. Antidotes.

* Please note the hour.

6. Tuesday, October 20.
Sulphur, Selenium, and Tellurium. Allotropic forms. Amorphous sulphur. Plastic sulphur. Lac sulphur. Halides of sulphur, of thionyl, and of sulphuryl. Similarity of selenium to sulphur. Photosensitivity. Tail-light glass. Alkali disease. Teledium.

7. Tuesday, October 27.
The Oxides and Acids of Sulphur. Catalysis on the grand scale: Manufacture of sulphuric acid. Permono-sulphates, Caro's acid, per-di-sulphates. Desmotropism in sulphurous acid. Thio salts. Hyposulphurous acid. Pyrosulphuric acid. Hydrogen sulphide.

8. Tuesday, November 3.
Chlorine. Liquefaction. Bleaching action. Germicidal action. Chlorination of drinking water and of swimming pools. Tests for active chlorine. Chloramines.

9. Tuesday, November 10.
Chlorine Acids and Other Chlorine Compounds. Detection in organic compounds and in chlorides. Chlorides, hypochlorites, chlorites, chlorates, and perchlorates. Double halides.

10. Tuesday, November 17.
Bromine, Iodine and Fluorine. The halogen family. Outer orbits in halogen atoms. Halogen acids. Perhalides. Binary compounds of halogens. Uses of the halogens. Halogens and goiter, physiologic salt solution, germicidal tincture of iodine, mottled teeth.

11. Tuesday, November 24.
Chromium, Molybdenum, and Tungsten. Multivalence. Tinctorial quality of chromium compounds. Chrome alum. Chromyl chloride. Chromates and polychromates. Chromite and chrome steel. Molybdenum and tungsten steels. Complex molybdates. Electrical uses of these metals.

12. Tuesday, December 1.
Vanadium, Columbium, Tantalum, Proactinium. Ferro-vanadium, chrome vanadium steel. Ferro-columbium in stainless steels. Vanadium in automobiles. Vanalium. Fansteel metal. Tantung. Tantaloy. Compounds of vanadium, of columbium, and of tantalum. Unique characteristics of proactinium.

13. Tuesday, December 8.
Boron, Scandium and Yttrium, and Actinium. Borides. Normal, meta, and pyro borates. Perborates. Tests for boric acid. The rate earths. Mendeleeff's prediction of properties of scandium. The place of actinium among the elements.

14. Tuesday, December 15.
The Colloidal State. Degrees and types of dispersions. Tyndall effect. Brownian movement. Electrical charges on colloid particles. Protective colloids. Gels and emulsions. Foams. Dusts, smoke, fog. Cotrell precipitator. Adsorption and gas masks. Ultra filters. Ultra microscopy. The flotation process in metallurgy.

ORGANIC CHEMISTRY 2

PROFESSOR GRIFFITH

Carbohydrates, Oils, Fats and Waxes

Lectures begin at 8 P. M.

1. Wednesday, September 16.
Cellulose—Framework of the Vegetable Kingdom. Its natural synthesis. Its molecular structure and its properties.

2. Wednesday, September 23.
Cellulose in the Service of Man. Texts: From *papyrus* to *pulp* to *paper.*

3. Wednesday, September 30.
Cellulose in the Service of Man. Textiles. From *fig-leaf* to *fiber* to *fabric*. The cellulose fibers—cotton—linen—ramie, etc.

4. Wednesday, October 7.
Chemicalized Cellulose—The *so-called* artificial silks, rayon, bemberg, celanese, etc. The plastics.

5. Wednesday, October 14.
Chemicalized Cellulose—Cellulose on the rampage. Gun cotton from cellophane to cellophobe.

6. Wednesday, October 21.
Starch—From sun and soil to sustenance. Its nature, distribution, and physico-chemical eccentricities.

7. Wednesday, October 28.
The Sugars—Occurrence in nature. The reasons for rations. Family traits of the sugars.

8. Wednesday, November 4.
The Sugars (Continued). Sugar and metabolism. Sugar versus saccharin.

9. Wednesday, November 11.
Oils, Fixed and Volatile. Proximate principles. Oils that will—and oils that will not—evaporate, saponify, dry, etc.

10. Wednesday, November 18.
Oils (Continued). The physics and chemistry of the fixed oils. Uses in foods and in the industries. Their role in modern war.

11. Wednesday, November 25.
Fats and Waxes. From vegetable and from *animal* sources. The synthetic waxes.

12. Wednesday, December 2.
Soaps. Proper fat or oil *plus* proper alkali *plus* proper technic makes soap and glycerin. Modern soaps. Soap hokum. How soap cleans.

13. Wednesday, December 9.
Soapless Soaps. The new detergents. Surface tension depressants and penetrants.

14. Wednesday, December 16.
Milk and its Ilk. The composition and uses of milk. Household tests and legal standards. From casein to cheese to carpet and clothing.

ENGINEERING 4

PROFESSOR WAGNER

Water Supply, Sewers, Canals, Rivers, and Harbors

Lectures begin at 7.45 P. M.*

1. Friday, September 18.
Hydrography. Water surveys of all kinds. Soundings. Current meters. Discharge of streams.

2. Friday, September 25.
Water Supply. Water and its impurities. Analysis—chemical and biologic. Interpretation of analysis.

* Please note the hour.

3. Friday, October 2.
   Water Supply (Continued). Sources of water. Consumption. Storage reservoirs.

4. Friday, October 9.
   Water Supply (Continued). Construction of reservoirs and dams of earth and masonry. Distributing systems. Aqueducts. Pipes.

5. Friday, October 16.
   Water Supply (Continued). Purification. Distilling. Boiling. Disinfection. Sedimentation. Filtration. Softening. Straining.

6. Friday, October 23.
   Water Supply (Concluded). Rapid and slow sand filters—their design and construction. Reduction of typhoid by filtration.

7. Friday, October 30.
   Sewers. Definitions. Sewerage systems. Requirements of a good system.

8. Friday, November 6.
   Sewers (Continued). Location. Determination of amount of sewage and storm water. Formulae.

9. Friday, November 13.
   Sewers (Continued). Size. Construction. Excavation and refilling.

10. Friday, November 20.
    Sewers (Concluded). Disposition. Processes for purification. Disposal of sludge.

11. Friday, November 27.
    Canals. Classification. History. Cross-section. Water supply. Reservoirs. Feeders.

12. Friday, December 4.
    Canals (Concluded). Levels. Locks. Locomotion. Ship canals.

13. Friday, December 11.
    Rivers. Natural features. Protection of banks. Bars. Inundations. Regulation. Slack water navigation.

14. Friday, December 18.
    Harbors. Roadsteads. Harbors, natural and artificial. Dikes. Sea walls. Breakwaters.

ZOOLOGY 3

MR. LAWRENCE

The Origin, Development, and Activities of Man Upon the Earth

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Lectures begin at 8 P. M.

1. Monday, January 4.
   The Earth before Man and as He Found It. Man's ancestors. His early struggles. Where he lived and how he lived. What he knew and what he thought.

2. Monday, January 11.

   Anthropology. Its meaning and scope. Methods of research. Sources of information. Results obtained.

3. Monday, January 18.

   Man's Conquest of the Earth. Traces of his early travels. Some human remains and relics that have been found. What they mean to us.

4. Monday, January 25.

   Men of the Old Stone Age. Their daily life. Their homes. Their food. Their clothes. Their tools.

5. Monday, February 1.

   Men of the New Stone Age. Life becomes more interesting. Better tools. More constructive work: houses, towers, monuments, and tombs. Pots, bowls, fire, and cooking. Grain becomes a food. Nature worship.

6. Monday, February 8.

   Men of the Bronze Age and the Early Iron Age. Better weapons and tools. Spinning. Weaving. The wheel. Trade and travel. The harvest. General conditions of life.

7. Monday, February 15.

   Prehistoric Culture. Various epochs of culture. The use of copper and gold for coins and ornamentation. Dress and personal adornment. Cave art. Religion.

   Monday, February 22. No lecture.

8. Monday, March 1.

   The Races of Man. Their origin, spread and characteristics. The mingling of races with the ensuing results. The effect of modern travel and communication on races.

9. Monday, March 8.

   The Social Life of Man. The family. The tribe. The state. Religion. Law and order. Education.

10. Monday, March 15.

    The Sweat of Man's Brow. Labor a blessing. Division of labor. Man's work. Woman's work. The products of labor. The agricultural age. The industrial age.

11. Monday, March 22.

    Modern Man. The development of the individual. His physical structure. His control systems. His long period of training. His value as an individual.

12. Monday, March 29.

    Man's Problem of Keeping Fit. Why we grow weak and suffer. Is modern life too easy? Habits and health. Food and health.

13. Monday, April 5.

    Man's Mastery over Evil Forces of Nature. Man and disease through the ages. The medicine man and the modern doctor. Some victories over disease.

14. Monday, April 12.

    What are the Possibilities of the Future for the Human Race? Will man destroy himself or will he achieve a glorious victory? Pros and cons in the case.

Field Trip

The class in Zoology will be conducted on a field trip under the leadership of Mr. Lawrence. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

GEOLOGY 4

Professor Howell

Historical Geology

Lectures begin at 7.45 P. M.*

1. Tuesday, January 5.
   The History of the Earth and Its Inhabitants. Why we try to learn it, and how we go about the learning.
2. Tuesday, January 12.
   The Origin and Early History of the Earth. Its condition when first a planet and the changes which followed.
3. Tuesday, January 19.
   Plants and Animals Appear on the Earth's Surface. How life originated and what its earliest forms were like.
4. Tuesday, January 26.
   The Cambrian Period. The first period of earth history of which we have a really good knowledge.
5. Tuesday, February 2.
   The Ordovician Period. The period when the animal life of the oceans became more diversified.
6. Tuesday, February 9.
   The Silurian Period. The period during which plants and animals first invaded the lands.
7. Tuesday, February 16.
   The Devonian Period. The fishes dominate life in the waters and land plants and animals evolve rapidly and spread widely.
8. Tuesday, February 23.
   The Carboniferous Period. The period when the great coal forests flourished.
9. Tuesday, March 2.
   The Permian Period. When great continental glaciers spread over the earth and the cold exterminated many plants and animals.
10. Tuesday, March 9.
    The Triassic Period. The earth grows warmer and new kinds of plants and animals appear.
11. Tuesday, March 16.
    The Jurassic Period. The huge dinosaurs dominate the land and many reptiles take to the seas.
12. Tuesday, March 23.
    The Cretaceous Period. The Age of Reptiles comes to an end and modern types of land plants evolve.
13. Tuesday, March 30.
    The Tertiary Period. Birds and mammals replace reptiles as the dominant animals of the lands.
14. Tuesday, April 6.
    The Quaternary Period. Continental glaciers again spread over the lands to set the stage of life on which we now live.

Field Trip

The class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

* Please note the hour.

PHYSICS 1

PROFESSOR SEELY

Properties of Matter, Measurement and Mechanics

Lectures begin at 8 P. M.

1. Wednesday, January 6.
   Man's Efforts to Understand the Material Universe. Masses, molecules, atoms and electrons. Properties of matter, measurement. States of matter.

2. Wednesday, January 13.
   Motion is Universal. Force. How objects without power to move themselves are made to move. How men study, classify and measure motion.

3. Wednesday, January 20.
   A Simple Fundamental Law of Motion. Newton's laws of motion. Momentum acceleration and inertia.

4. Wednesday, January 27.
   Motion is Not Always Simple. Complicated motions may be simplified for study. Whirling and spiral motions.

5. Wednesday, February 3.
   How Work Gets Done and is Measured. Force and energy. Energy is never created or destroyed.

6. Wednesday, February 10.
   A Great Man Thinks about Falling Bodies. Newton's law of gravitation. Weight, equilibrium and stability.

7. Wednesday, February 17.
   How Motion of Falling Bodies is Measured. Bodies falling vertically. Paths of projectiles. The pendulum.

8. Wednesday, February 24.
   Man's Intelligence Leads Him to Use Tools and Machinery. Six simple machines. The law of intake and output.

9. Wednesday, March 3.
   Machinery is Limited in its Uses. Efficiency. Friction, tension and thrusts.

10. Wednesday, March 10.
    Liquids May be Used to Increase Force or Speed of Action. Liquid pressure. The hydrostatic paradox.

11. Wednesday, March 17.
    Why Some Bodies Float in Water. Buoyancy. Density and specific gravity.

12. Wednesday, March 24.
    How Liquids Rise in Tubes. Surface tension. Surface films and capillarity.

13. Wednesday, March 31.
    The Turbulent Ocean in Which We Live. Atmospheric pressure. Barometers. Weather maps. Compressibility of gases.

14. Wednesday, April 7.
    How the Properties of Gases are Studied and Measured. Three gas laws. Atmospheric density and buoyancy.

MUSEUM TALKS

Monday evenings at 7 o'clock

This series comprises informal talks, given on Monday evenings, in the Museum, illustrated by specimens.

PROFESSOR HOWELL

Minerals, Rocks, and Fossils

Sept. 14. The Minerals of Which Rocks are Composed.
Sept. 21. Rocks Formed of Materials from Within the Earth's Crust.
Sept. 28. Rocks Formed as Sheets on the Earth's Surface.
Oct. 5. Plant Fossils, which tell us About the Vegetation of the Past.
Oct. 12. No Lecture.
Oct. 19. The Fossil Record left by the Invertebrate Animals of Bygone Ages.
Oct. 26. The Buried Bones of the Vertebrates and the Story They Tell.

MR. LAWRENCE

Some Relations of Insects to Man

Nov. 2. Household Insect Pests and How to Deal with Them.
Nov. 9. Insects Injurious to Vegetation and Some Ways of Meeting the Problems.
Nov. 16. The Devastations of Termites.
Nov. 23. Insects as Food for Animals and Man.
Nov. 30. Insects and Disease.
Dec. 7. Insects that are Distinctly Beneficial to Man.

MISS BORDEN

Animal Life in the Warmer Seas

Dec. 14. Animals that look like Seaweeds.
Dec. 21. Flower-like Animals that serve as Death-traps.
Dec. 28. No Lecture.
Jan. 4. Rock-builders of the Ocean.
Jan. 11. Sheltered Lives of Creeping Stars and Sea Baskets.
Jan. 18. Animated "Chestnut-burs"—Cucumbers and Lilies of the Sea.
Jan. 25. Ecology of the Coral Reef, where Life is Swift and Uncertain.

MR. HOPE

Animal Technology

Feb. 1. Animal Hunters and Fishers: Gins, Snares and Blinds. Agriculturists.
Feb. 8. Animal Artisans: Carpenters, Masons, Papermakers and Weavers.
Feb. 15. Engineering Skill in the Animal World. Dams and Tunnels.
Feb. 22. No Lecture.
Mar. 1. Animal Architects. Private and Community Housing.
Mar. 8. Locomotion of Animals.
Mar. 15. Animal Communications. The Fine Arts of Music and Warfare.

PROFESSOR KAISER

Great Groups of Plants

Mar. 22. Duckweed, Dayflower, Pickerel Weed, Pineapple.
Mar. 29. Buckwheat, Goosefoot, Pigweed, Poke.
Apr. 5. Stonecrop, Houseleek, Saxifrage, Currant.
Apr. 12. Pinks and Portulacas.
Apr. 19. Holly, Bittersweet, Bladdernut, Maple.
Apr. 26. Tea, Saint John's Wort, Waterwort, Rock Rose, Violet, Passion Flower.

GENERAL SCHEDULE OF REGULAR LECTURES

Subjects of courses in each of the four successive years constituting a full term

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles and Theories. Notation. Non-Metals.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

ZOOLOGY

1. Invertebrate Animals.
2. Vertebrate Animals.
3. Human Biology.
4. Principles of Animal Life.

BOTANY

1. Morphology.
2. Taxonomy.
3. Taxonomy (continued).
4. Physiology and Ecology.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

LECTURES UNDER RICHARD B. WESTBROOK FOUNDATION

1912.—Ancient Civilization of Babylonia and Assyria. *Morris Jastrow, Jr., Ph.D.*
1913.—Conservation of Natural Resources.
Gifford Pinchot, Marshall O. Leighton, Overton W. Price, Joseph A. Holmes.
1914.—The Theory of Evolution. *William Berryman Scott, Ph.D., LL.D.*
1915.—Invisible Light. *Robert Williams Wood, LL.D.*
1916.—Aspects of Modern Astronomy. *John Anthony Miller, A.B., A.M., Ph.D.*
1917.—Heredity and Evolution in the Simplest Organisms.
H. S. Jennings, B.S., A.M., Ph.D., LL.D.
1918.—The Chemistry, Nutritive Value and Economy of Foods.
Harvey W. Wiley, A.M., M.D., B.S., Ph.D., LL.D., D.Sc.
1919.—The Origin and Antiquity of the American Indian.
Aleš Hrdlička, M.D , Sc.D.
1920.—Chemistry and Civilization. *Allerton S. Cushman, B.S., A.M., Ph.D.*
1921.—Microbiology. *Joseph McFarland, M D., Sc.D.*
1922.—Evolution of the Human Face. *William K Gregory, Ph.D.*
1923.—The Philosophy of Sanitation. *George C. Whipple, B.S.*
1924.—The Distribution of American Indian Traits. *Clark Wissler, A.M., Ph.D.*
1925.—Structural Colors. *Wilder D. Bancroft, Ph.D., Sc.D.*
1926.—The Animal Mind; its sources and evolution. *George Howard Parker, Sc.D.*
1927.—An Interpretation of Atlantic Coast Scenery. *Douglas W. Johnson, Ph.D.*
1928.—The Science of Musical Sounds. *Dayton C. Miller, Ph.D.*
1929.—Volcanoes and Vulcanism. *William B. Scott, Ph.D., LL.D.*
1930.—Present Problems of Evolution. *Edwin Grant Conklin, Ph.D., Sc.D., LL.D.*
1931.—The Problems of the Origin and Antiquity of the American Aborigines in the Light of Recent Explorations. *Aleš Hrdlička, M.D., Sc.D.*
1932.—Common Sense, Science and Philosophy. *John Dewey, Ph.D., LL.D.*
1933.—Social Relations in Monkey, Ape and Man.
Robert M. Yerkes, A.M., Ph.D., Sc.D.
1934.—Chemistry and Industrial Progress as Exemplified in the Study of Hydrogen and Oxygen. *Hugh S. Taylor, D.Sc., F.R.S.*
1935.—Recent Progress in Astronomy. *Samuel A. Mitchell, M.A., Ph.D., LL.D.*
1936.—Real Lilliputians of the Universe. *Ellis L. Manning.*
1937.—Biology and Social Problems. *Edwin Grant Conklin, Ph.D., Sc.D., LL.D.*
1938.—Emotions and the Social Order. *Frederick H. Lund, A.M., Ph.D.*
1939.—The Making and Mixing of Human Races.
Earnest A. Hooton, Ph.D., B.Litt., Sc.D.
1940.—Atomic Nuclei and Atomic Transmutations.
Kenneth T. Bainbridge, S.M., Ph.D.
1941.—Geography and Its Influence on History. *Derwent Whittlesey, Ph.D.*
1942.—From Nature Through the Test Tube to Textiles and Plastics.
Jesse W. Stillman, A.M., Ph.D.

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Can be purchased through any book-store

Ancient Civilization of Babylonia and Assyria, by *Morris Jastrow, Jr.* J. B. Lippincott Co.
The Theory of Evolution, by *William Berryman Scott.* The Macmillan Co.
Life and Death, Heredity and Evolution in Unicellular Organisms, by *H. S. Jennings.* Richard G. Badger.
Chemistry and Civilization, by *Allerton S. Cushman.* Richard G. Badger.
Fighting Foes too Small to See, by *Joseph McFarland.* F. A. Davis Co.
The Relation of Nature to Man in Aboriginal America, by *Clark Wissler.* Oxford University Press.

PUBLICATIONS OF THE INSTITUTE

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Notice of Some Fossil Human Bones. *Joseph Leidy.*
Description of Mammalian Remains from Rock Crevice in Florida. *Joseph Leidy.*
Description of Vertebrate Remains from Peace Creek, Florida. *Joseph Leidy.*
Notice of Some Mammalian Remains from Salt Mine of Petite Anse, Louisiana. *Joseph Leidy.*
On Platygonus, an Extinct Genus Allied to the Peccaries. *Joseph Leidy.*
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Part 6, Conclusion. Pelecypoda and Brachiopoda General Summary of Geological and Paleontological Results	3.50

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PUBLICATIONS

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BULLETIN

Bulletin of the Institute. Quarterly $1.00 per year
Single numbers, 25 cents.

Republication of Conrad's Fossils of the Medial Tertiary of the United States. Introduction by *William H. Dall.* (Out of Print.)

Illustrated Catalog of North American Devonian Fossils, Unit 7B, Ammonoidea. $2.50 (Plus Packing and Postage). Unit 9A, Beyrichiacea, $5.50 (Plus Postage). Unit 3A, Fenestrellinidae, $13.50 (Plus Postage). Unit 1D, Graptolithina, 65 cents (Plus Packing and Postage). Unit 11, Merostomata, 85 cents (Plus Packing and Postage).

BULLETIN
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WAGNER FREE INSTITUTE OF SCIENCE
PUBLISHED BY THE INSTITUTE
SYDNEY L. WRIGHT, *Editor*

Vol. 17 No. 4	Quarterly NOVEMBER, 1942	$1.00 per year Single numbers, 25 cents

NEW SILURIAN ASTYLOSPONGID FROM TENNESSEE

By B. F. HOWELL, A.M., PH.D.

Through the courtesy of Professor C. W. Wilson, of Vanderbilt University, the writer has been able to examine six fossil sponges from the Upper Niagaran Middle Silurian Brownsport Formation, about 2½ miles south of Perryville, Decatur County, Tennessee, which have proved to be examples of a new species of *Palaeomanon*, a genus long known from this region, so famous for its Silurian sponges. With Professor Wilson's kind permission these sponges are here described.

Phylum Porifera
CLASS: Silicispongiae
SUBCLASS: Tetraxonida
ORDER: Lithistida
SUBORDER: Eutaxycladina
FAMILY: Astylospongidae
Palaeomanon elongatum, new species
Pl. 1, figs. 1–9

Body urn-shaped, the exact form different in different individuals, but always more elongate than in the related and variable species, *Palaeomanon cratera* (Roemer). The diameter of the body is always reduced near the osculum, and the osculum is relatively narrow and shallow. Although the sponges were probably attached in life, the area of attachment would seem to have been small, for the lower ends of the fossils are bluntly rounded and show no evidence of a broken anchor.

The surface of the six specimens studied appears, when viewed through a microscope, to be granular and finely pitted, because the spicules, which seem to have formed a strong and compact skeleton which retains its form in the fossils, have had enough silica added since the burial of the animal to make their form indistinct, but not enough to fill the canals between them. Traces of the circular apertures of the exhalant tubes which end in the depres-

sion of the osculum and which are so characteristic of some other species of *Palaeomanon* can be seen in some of our specimens, but in no one of our fossils are they well displayed. Faint, uneven, longitudinal furrows, running downward from the edge of the osculum, such as can be seen on some other species of *Palaeomanon*, can also be detected on two of our specimens.

Indistinct evidence of the arrangement of the parts of the interior of the sponges can be seen in one of our specimens, which shows traces of narrow silica-filled, perpendicular chambers, or canals, radiating from the axis of the body as they do in other species of the Astylospongidae.

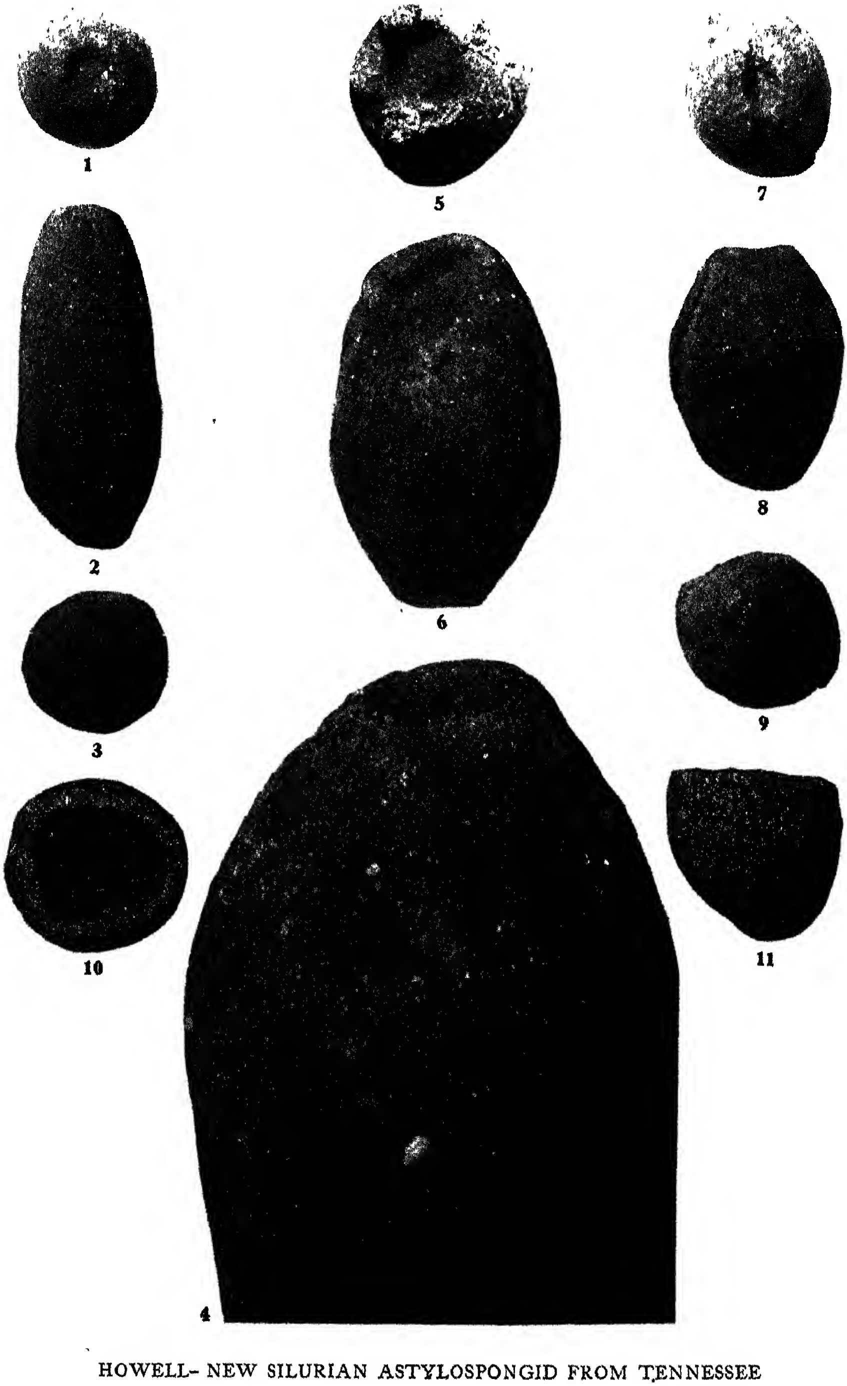
It is difficult to determine the exact form of the spicules in our fossils, but they appear not to differ from those found in other species of *Palaeomanon*.

Comparison with other species: *Palaeomanon elongatum* is obviously closely related to *Palaeomanon cratera* (Roemer) and the numerous varieties of that species which have been described by Rauff.* It differs from *P. cratera* and all its varieties in being more elongate in form and in having a more constricted osculum. It is nearest to *P. cratera lecythium* (Rauff) in shape, but is taller than that species, is relatively more constricted at its upper end, and has a relatively smaller osculum. A large collection of specimens of *P. elongatum* might be found to include some examples which were very similar in form to *P. cratera lecythium;* but, if our six fossils are typical of *P. elongatum*, the average sponge of our species differs too much in form from *P. cratera* to be looked upon as a variety of that species and deserves full specific rank.

Location of types: The holotype is No. S1 in the paleontological collection of Vanderbilt University. Paratypes are Nos. S2 and S3 in the same collection, and 53050–53052 in the paleontological collection of Princeton University.

The writer wishes to express here his appreciation of Professor Wilson's kindness in permitting him to describe these fossils.

* Rauff, Hermann. Palaeospongiologie. Palaeontographica, vol. 40, 1894, pp. 314–320, pls. 11–13.



HOWELL–NEW SILURIAN ASTYLOSPONGID FROM TENNESSEE

EXPLANATION OF PLATE

Fig. 1: *Palaeomanon elongatum* Howell. Top view of holotype. ×1. No. S1. Vanderbilt Univ. Brownsport Formation, Middle Silurian. About 2½ miles south of Perryville, Tennessee.

Fig. 2: *Palaeomanon elongatum* Howell. Side view of holotype. ×1.

Fig. 3: *Palaeomanon elongatum* Howell. Bottom view of holotype. ×1.

Fig. 4: *Palaeomanon elongatum* Howell. Side view of upper end of holotype, enlarged, to show external details of skeleton. ×4.

Fig. 5: *Palaeomanon elongatum* Howell. Top view of paratype from which part of rim of osculum has been broken away, showing faint traces of upper ends of perpendicular chambers, or canals, at central axis. ×1. No. S3, Vanderbilt Univ. Brownsport Formation, Middle Silurian. About 2½ miles south of Perryville, Tennessee.

Fig. 6: *Palaeomanon elongatum* Howell. Side view of paratype, a more globose individual than the holotype. ×1. No. 53050, Princeton Univ. Brownsport Formation, Middle Silurian. About 2½ miles south of Perryville, Tennessee.

Fig. 7: *Palaeomanon elongatum* Howell. Top view of paratype, a relatively globose individual. ×1. No. S2, Vanderbilt Univ. Brownsport Formation, Middle Silurian. About 2½ miles south of Perryville, Tennessee.

Fig. 8: Side view of same specimen.

Fig. 9: Bottom view of same specimen.

Fig. 10: *Palaeomanon cratera* (Roemer). Top view of example of this species for comparison with specimens of *Palaeomanon elongatum*. ×1. No. 43564, Princeton Univ. Niagaran, Middle Silurian. Perry County, Tennessee.

Fig. 11: Side view of same specimen.

BULLETIN
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PUBLISHED BY THE INSTITUTE

SYDNEY L. WRIGHT, *Editor*

Vol. 18 No. 1	Quarterly FEBRUARY, 1943	$1.00 per year Single numbers, 25 cents

AN INVESTIGATION OF THE LITTER FAUNA OF TWO TYPES OF PINE FOREST

JOHN G. HOPE
Curator, Wagner Free Institute of Science

INTRODUCTION

The study the results of which are presented herewith was undertaken primarily to obtain a picture of the floor fauna of the Pine Barren region of New Jersey. It was considered that it would be illuminating to compare this fauna with that of another type of pine forest, and for this a stand of Hemlock, *Tsuga canadensis*, was chosen.

Unfortunately, the field work was somewhat limited.* While no very general conclusions should be drawn from the results of the number of samples studied, it is felt that sufficient material has been obtained to warrant publication. This is especially true in view of the fact that almost nothing has been published in this field.

The Pine Barren region of New Jersey is highly interesting to the biologist. A good phytoecologic description has been published by Harshberger (1916). There are other papers on the fauna and flora, but to the writer's knowledge no floor fauna study has ever been made before.

The stand of Hemlock chosen for comparative study is located along the Wissahickon Creek in Philadelphia. It appears to represent a portion of primeval forest.

The field work was done in July and August, 1942.

MATERIAL AND METHODS

The Pine Barrens material was collected about one mile south of Albion, New Jersey. The forest here is a fairly open one of *Pinus rigida*, the Pitch Pine, and has been, apparently, long undisturbed. The scant undergrowth consists of sapling pines, seedling oaks and sassafras, cat-briar, holly and a very few herbs. The litter consists of pine needles, twigs and cones, some pieces of bark and a few oak leaves.

* Field work was curtailed by the entry of the author on active duty in the USNR.—[ED.]

Samples representing the Hemlock forest were taken from a stand along the Wissahickon Creek, in Fairmount Park, Philadelphia. Here *Tsuga canadensis* forms pure association on precipitous cliffs of gneiss overlooking the creek. One finds an occasional beech or cherry, but the second-story is practically non-existent. There are extremely few seedling hemlocks and red maples. Some moss forms patches on the ground and lichens grow on the rocks, which are everywhere exposed.

In no case had there been any precipitation within twenty-four hours preceding the collections. Certain physical and chemical investigations were carried out and the methods used are described together with the results.

Collecting was of two kinds—manual and by the Berlese method. In manual collecting a quadrat frame, 25 cm. on a side, was used. This was placed at random on the forest floor, and the litter and humus contained down to soil level carefully examined piece by piece over a square of white canvas. All animals seen were placed in vials of 70% alcohol. This is a very tedious procedure and requires two or three hours to completely examine one quadrat. Animals from two such quadrats were lumped together and reported as one unit.

Certain prominent and characteristic animals of the litter, such as springtails and mites, cannot be satisfactorily collected in this manner. These were collected separately by the use of the Berlese funnel. This consists of a large funnel of metal or even cardboard. A small glass vial is placed under the apex and the material to be examined supported on a screen placed a few centimeters below the rim of the funnel. As the material dries the mites and springtails drop through the screen and are caught in the vial, where they may be killed by applying boiling water or alcohol. In its original form the Berlese funnel was steam-jacketed to hasten the operation. However, heat has been proved lethal to many of the organisms, consequently it should not be used, especially in quantitative work. All of the material from a quadrat (not previously examined manually) was brought back to the laboratory and weighed. Then an aliquot portion was placed on the screen of the Berlese funnel and extracted without the use of heat until exhausted, after the method of Jacot (1936). The animals which had dropped in the tubes were killed at the end of each day and preserved in alcohol. These were examined with the microscope, over a blue background ruled into squares and counted. From the ratio of the aliquot to the entire sample an estimate of the total number of these forms was made.

Environmental Factors

From the investigations of previous workers certain environmental factors seem to have the greatest influence on the fauna of the forest floor. Two of these are considered here—structure of the substratum and litter moisture.

Structure.—Romell and Heiberg have prepared a classification of the types of humus layer in the forests of the Northeastern United States (1931). According to their descriptions, the litter from the Pine Barrens corresponds most closely to their "Fibrous Duff"; and that from the hemlock forest to their "Greasy Duff." In the former, the F-layer is well developed and the H-layer fibrous and not very compact. A layer of relatively dry needles is

underlain by the much more damp humus. This in turn lies on moist, white sand from which it is clearly demarcated. The F-layer averages 2.5 cm. and the humus layer 3 cm. in depth. The hemlock litter agrees well with the description of "Greasy Duff" in that the F-layer is little developed, the H-layer relatively thick and compact, black and muck-like. However, the H-layer does not attain the thickness (1 dm. or more) reported by Romell and Heiberg in their description. The average thickness of the F- and H-layers is 3.5 cm. There is no sharp demarcation between the litter and the micaceous soil on which it lies, as in the case of the Pine Barren litter.

Litter Moisture.—At the time of each collection a sample of the litter was brought back to the laboratory in a waxed paper carton. This was weighed upon arrival (in no case more than a few hours after collection) and then dried at room temperature for several days and weighed again. The difference in weighings was taken as litter moisture. The results are shown below:

Pine Barrens	A.	30%	moisture
" "	B.	37%	"
Hemlock	A.	29%	"
"	B.	15%	"

In both cases the hemlock samples show less moisture than those from the Pine Barrens. This is borne out by observation. The hemlock grows on rocky cliffs where run-off is more rapid and the litter consequently apt to be somewhat drier.

CHEMICAL EXAMINATION OF THE LITTER

At the time of each collection a sample was taken for chemical examination. The sample was screened to remove large pieces of débris and the final sample taken by repeated quartering. This was examined by the method of Morgan (1937). pH was determined by the method of Wherry (1920). The results are given in the following table:

	Pitch Pine		*Hemlock*	
	A	*B*	*A*	*B*
Nitrate nitrogen	..	..	..	..
Ammonia nitrogen	low	low	trace	..
Phosphorus	very low	low	trace	very low
Potassium	..	..	..	..
Calcium	very low	very low	trace	trace
Magnesium	med.	low	very low	very low
Aluminum	low	med. high	med. high	med. high
Manganese	..	..	..	..
pH	5.0	5.0	5.5	5.5

It is felt that insufficient work on material of this type with this method has been done to warrant publication of values in terms of p.p.m., but the results are useful for comparison of the two types. The two types of litter are essentially similar chemically. In neither case is there sufficient nitrate nitrogen, potassium or manganese present to measure by this method. The pH is approximately the same. The values for NH_3 nitrogen and magnesium are slightly higher for the Pine Barrens litter.

The Collections

The results of the collections are presented below:

Manual Collections

	Pitch Pine A	Pitch Pine B	Pitch Pine C	Pitch Pine Total	Hemlock A	Hemlock B	Hemlock C	Hemlock Total
PHYLUM—MOLLUSKA								
Class—Gastropoda	1	..	..	1	..	..	..	..
PHYLUM—ANNELIDA								
Class—Oligochaeta	..	6	2	8	..	..	..	..
PHYLUM—ARTHROPODA								
Class—Arachnida								
Order—Phalangida	..	..	..	..	1	..	..	1
—Araneida	3	6	15	24	1	..	..	1
Class—Chilopoda	4	..	..	4	..	2	6	8
Class—Hexapoda								
Order—Corrodentia								
Family—Psocidae	1	..	..	1	..	..	..	..
Order—Thysanoptera	1	..	..	1	..	..	..	..
Order—Hemiptera								
Family—Dipsocoridae	..	1	7	8	..	..	..	..
—Reduviidae	..	..	2	2	..	..	..	..
Order—Diptera	..	(3)	(3)	(6)	(1)	(1)	..	(2)
Family—Cecidomyidae	..	..	..	..	..	1	..	1
—Tipulidae	..	..	..	..	..	..	(1)	(1)
Order—Coleoptera								
Family—Carabidae	2	(3)	(2)	7	1	..	..	1
—Staphylinidae	..	2	1	3	..	..	..	..
—Elateridae	(4)	(1)	..	(5)	(1)	(1)	(1)	(3)
—Scarabaeidae	..	..	..	..	1	(1)	..	2
—Chrysomelidae	..	..	1?	1	..	..	..	..
—Undet.	..	..	..	..	..	1	..	1
Order—Hymenoptera								
Family—Formicidae†								
Sub-Family—Myrmecinae	3	16	..	19	5	..	..	5
—Ponerinae	9	7	4	20	4	2	1	7
TOTALS	28	45	37	110	15	9	9	33

Notes: Each column represents the population of two quadrats 25 cm. on a side. Numbers representing larval forms are enclosed in brackets.

† This method of collecting does not give a good indication of the true numbers of such highly mobile and far-ranging forms as the ants.

Berlese Collections

(1 quadrat—25 cm. on a side)

	Pitch Pine	Hemlock
PHYLUM—ARTHROPODA		
Class—Arachnida		
Order—Acarina	5,422	3,925
Class—Hexapoda		
Order—Collembola	3,192	37
TOTALS	8,614	3,962

Percentages of Population Constituents

The Collembola and Acarina so greatly overshadow the other groups numerically that they tend to mask the relative importance of the forms taken manually. Therefore the Berlese collections and the manual collections

are considered as two units. All percentages are based on the total population of six quadrats for each type of litter.

	Pitch Pine		*Hemlock*	
	No.	%	*No.*	%
Acarina	32,532	62.81	23,550	98.93
Collembola	19,152	36.98	222	0.93
Total	51,684	99.79	23,772	99.86
All others	110	0.21	33	0.14
Total	51,794	100.00	23,805	100.00

PERCENTAGES OF FORMS EXCLUDING COLLEMBOLA AND ACARINA

	Pitch Pine	*Hemlock*
Hymenoptera (ants)	35.46	36.36
Araneida	21.82	6.06
Coleoptera (beetles; larvae and adults)	14.55	21.42
Heteroptera (bugs)	9.09	..
Oligochaeta (bristle-worms)	7.27	..
Diptera (flies; larvae and adults)	5.46	12.12
Chilopoda (centipedes)	3.64	24.24
Corrodentia	0.91	..
Thysanoptera	0.91	..
Gastropoda (snails)	0.91	..

DISCUSSION

Examination of the tables reveals a large litter fauna from these two types of forest, although most of the forms are barely visible to the unaided eye.

Three Phyla are represented, but the Arthropods are in the majority almost to the exclusion of the others. Gastropods are represented by only one specimen and Oligochaete worms by eight specimens from the Pine Barrens. Both are lacking in the Hemlock fauna.

The Arthropods are the highly characteristic group of this ecologic niche. Of these, the Springtails and Mites together form 99.79% and 99.86% of the litter fauna of the Pinus and Tsuga forest respectively. While these figures agree closely, it should be noted, however, that the Collembola form only .93% of this group in the case of the Tsuga litter whereas in the Pinus litter they comprise 36.98% of the group. Their almost entire absence from the former may possibly be due to lower litter moisture. Doubtless they are more sensitive to the presence or absence of moisture than are the mites. In extracting them with the Berlese funnel it was noted that species vary in their moisture sensitivity. Thus on the first day the majority of specimens taken were of one species, on the second day a different kind appeared in numbers, etc. This means that some are highly sensitive to drying and are taken early. The most resistant species are not taken for four or five days and there is a well-graded series between.

Three groups account for 71.83% of the specimens taken manually from the Pinus litter. These are the Ants—35.46%; Spiders—21.82% and Beetles—14.55%. Although so heavily outweighed in numbers by the Mites and Springtails, these are characteristic groups of the litter. In the case of the Tsuga litter, excluding the Mites, the characteristic groups are the Ants—

36.36%; the Centipedes—24.24% and the Beetles—21.42%. The Chilopods, which form a relatively high percentage of this fauna, comprise only 3.64% of the manual collections from the Pine Barrens. On the other hand, the Spiders which are abundant in the Pinus litter drop to 3.03% of the hand collections from the Tsuga.

Comparison with Other Investigations

Not many inquiries of this sort have been carried out. Perhaps the most complete to come to the attention of the author is that of Williams (1941), who studied the floor fauna of the Panama Rain Forest. As might be expected, he encountered a far greater variety of forms. Five Phyla are represented in his collections, with thirty-seven orders.

He found that Collembola formed 32% to 36% of the litter population, and Acarina 24% to 25%. Taken together, these groups comprise 56–61% of the total population—a figure far below that obtained in the present study. It is suggested that Williams' figures for these groups are too low. Because of high humidity he had to extract his material with the aid of heat and extracted each sample for only six or seven hours. Jacot estimates that the Berlese system, used critically (without heat and over a period of days), is not more than 80% efficient.

Number Per Square Meter

Based on the samples examined there is for the Pitch Pine forest an estimated 138,112 animals per square meter. For the Hemlock, the number is less than half as many—63,480. Based on his "small quadrats" Williams found an average of 9,822 animals per square meter.

Biomass

Lunn (1939) determined the biomass in her study of leaf and log mold of Carlé Woods, Des Plaines, Illinois. Using the average weights of forest floor animals given by her, Williams determined the biomass of the litter of the Panama Rain Forest as 15.53 grams per square meter. In the present study—using the same figures—there was found to be 4.54 grams per square meter of Pinus forest floor and 2.06 grams per square meter of Hemlock forest floor. This is an underestimate, for the figures include only Oligochaetes, Coleopterous larvae, Coleopterous adults, larval Diptera, Acarina and Collembola.

Summary

This study is based on a limited number of samples from stands of the Pitch Pine, *Pinus rigida*, and Hemlock, *Tsuga canadensis*. Methods of collection are described.

A description of several environmental factors is presented—the structure of the substratum, litter moisture and the chemical characteristics of the litter.

A list of the animals collected is presented. These represent three Phyla and thirteen orders.

Faunal percentages were computed. Acarina represent 62.81% of the Pinus fauna and 98.93% of the Tsuga fauna. Collembola represent 36.98% of the Pinus and 0.93% of the Tsuga. The Hemlock litter fauna is poorer both in variety and in numbers of animals. The Arthropods are the characteristic animals in both cases.

The results are compared with those obtained by Williams, who worked in the Panama Rain Forest. He secured a greater variety of forms representing five phyla and thirty-seven orders.

The number of animals per square meter was estimated as 138,112 from the Pinus and 63,480 from the Tsuga. These figures are much higher than those obtained by Williams and it is suggested that his Acarina-Collembola count is far too low.

The biomass was estimated as 4.54 grams per square meter for the Pinus and 2.06 grams for the Tsuga. Williams' figure for the Rain Forest is 15.53 grams. All of these are low because all of the forms found were not considered in arriving at these figures.

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A SYNOPSIS ON THREE LECTURES ON THINKING: SOME PROBLEMS AND SOLUTIONS

(Delivered under the Richard B. Westbrook Free Lectureship, 1943)

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LECTURE I

HISTORICAL INTRODUCTION

To the question: "What is thinking?" several solutions have been given which we shall examine as we try to arrive at a satisfactory definition and theory of the thought processes. Before we can consider the answers which have been given to this question we must first note how thinking is distinguished from other psychological processes in order to exclude all types of activity not relevant to our main problem. The following characteristics may serve as tentative criteria of thinking:

(1) Thinking is a central activity, that is, it is due to the activity of the central nervous system. In this sense it is something which goes on "in our minds" but this does not mean that it is not a characteristic of behavior as well, for thinking, no less than all other psychological processes, is associated with behavioral activity and as such is objectively discernible. Thoughtful behavior differs from aimless behavior in ways that even the uninitiated easily recognize. We shall later discuss the objective signs of thinking.

(2) Thinking is a kind of doing or manipulating since it is concerned with the solution of problems of all kinds. Because thinking consists of mental manipulations the thinker is not bound by the limitations of handling concrete objects and hence he has a wider and freer world in which to work. Thinking thus allows us to realize all possibilities inherent in any problem-situation if we have the ability to probe them.

(3) Thinking is creative. Something new is discovered or made when the thought process achieves a proper solution to the problem it sets about to solve. This is the chief characteristic of thinking as distinguished from all

other central processes. It excludes much that passes for thinking such as mere reproduction of previously learned materials, reveries and fruitless imaginings.

How Do We Think?

The question of how we think involves the content and the operations of thinking. The two cannot be separated but we may consider them in turn. One of the earlier views of thinking held that the "laws of thought" are the laws of logic or that thinking to be fruitful must proceed according to certain established rules of logic. This view is erroneous in that it does not distinguish between thinking from the point of view of the thinker and the finished products of thinking which are presented for the benefit of others. From the point of view of the thinker his thinking satisfies him whether or not it is well-founded, logical, consistent, or fruitful. Thinking may proceed by hunches, guesses, intuitions, sudden flashes, and leaps having no logical basis. True conclusions may be reached from false premises whether or not thinking is "logical." The ordinary logical transitions from premises to conclusions may be reversed and the conclusion reached before there is any grasp of the correct premises. It is only when we subject our thinking to verification and wish to convince others that we attempt to formulate a logically tight thought-structure. Because the end product is logically perfect does not mean that we should advise those who would think to utilize only logical processes. It is perhaps more necessary to formulate an hypothesis than to seek to deduce one from premises by logical means. Once the fruitful hypothesis has been found there are always experiments and reasonings to prove it.

Empiricist-Associationist Theory

Regarding the content of thought two great philosophical schools have stood for widely different points of view. The Rationalists have asserted that thinking is an innate power of the mind, functioning according to innate categories of time, space, and even logical forms. Against this view the Empiricists have asserted the primacy of experience from which all the contents of thinking are derived. Our interest in the views of these opposed schools of philosophy lies in the fact that modern experimental approaches to thinking have been influenced by one or the other. Most of the experimental studies owed both their bias and interpretation to the British Empiricists and their successors, the English Associationists, with only a few showing the influence of the rationalistic view. Locke, concerned to show that there are no innate ideas or necessary truths of any kind whatsoever asserted that all knowledge is from experience. Ideas as objects of thought arise from either sensation or reflection. Reflection consists in the perception of the operations of our own minds. Understanding is based on these two sources of knowledge which ultimately reduce to only one. Bishop Berkeley saw in the concept of matter an abstraction which he believed was the source of all atheism and impiety. He therefore argued that all abstractions reduce to sensations which are the only ultimate reals. It was only a small step for Hume to deny all necessary connections and to assert that the notion of cause and effect is only

a matter of habitual associations. In similar vein the British Associationists reduced all mental operations to the so-called laws of association.

Thinking as association has thus had the weight of philosophical authority and historical tradition. Associationist logic is simple and appealing: simple sensational units, or their counterparts, images, are knit together by association to form trains of thought. Thinking on this view reduces to a problem of the conditions and kinds of association. The implications of this view are many and, in the hands of some modern psychologists and educators have influenced educational theory and practice to a great extent. Some of the implications of associationistic theory, both historically and in more modern form, are: integrated trains of thinking arise from simpler, unordered elements through association which in turn is aided by recency, frequency, and pleasantness; general ideas or concepts are only specific instances multiplied until, by some unexplained process, generalization is made; concepts transfer in so far as new situations have elements in common with previously experienced events. According to this view the intellectual processes stressed by the Rationalists, understanding, comprehension, and awareness of structure, are completely neglected or explained as a result of association.

Criticisms of Association

While certain philosophers, notably Bradley, had seen the inadequacy of associationism, the first criticism to come from the laboratory sprang from experiments on association. Mayer and Orth were told by their subjects who were asked to respond to stimulus words with associated words that more than association was involved in their replies. Other experiments by other members of what came to be known as the Wurzburg or Imageless Thought School agreed that more was necessary for orderly thinking and the solution of problems than association. Supplementing association were said to be conscious attitudes, mental set, purpose, type of problem, and thoughts which were not palpable and hence called "Imageless Thought."

The work of the Imageless Thought School gave no satisfactory solution to the problems it raised chiefly because no one at that time was willing to make a radical break with the underlying assumptions of associationism. Several important gains, however, were made in these investigations: the uniqueness of thinking as a process was recognized; theories involving more than the immediate data of experience were formulated and laid the basis for later broader approaches to thinking; new types of psychological experiments and tests were invented, many of them to be used later in intelligence, educational, and achievement tests. The central problem of the Imageless Thought School still receives no univocal answer: Do we need images in order to think? Some types of thinking obviously involve the use of concrete imagery while others do not, at least with some people. Images may help or hinder thinking; associations may help or hinder thinking depending upon the type of problem and what we have at our command to meet problem-situations.

The commonly-held view that mental ability depends upon the number and variety of associations is contradicted by the intelligence of individuals

having abnormally large numbers of facts and associations but of only average or below average intellectual capacity. "K," a vaudeville performer, is a case in point. He knew the population of every town and city in the United States over 5,000 by the 1920 census, the names and number of rooms and location of about 2,000 leading hotels, the county seats of all counties, the population of 1,800 leading foreign cities, the distances of all cities in this country from New York and Chicago and from each city and town to the largest city in its state, statistics concerning over 3,000 mountains and rivers, dates and essential facts connected with over 2,000 leading inventions and discoveries. Yet when tested at Columbia University his mental age was only 11 years and 10 months with the Stanford Revision, giving him an I.Q. of 0.74. An attempt to give him the Army Alpha test failed because of his confusion in taking directions. Something more than association is necessary for intellectual grasp and fruitful thinking which associationistic theories have overlooked.

The problem is not: Do we have associations? but: What gives sense and direction to thinking processes? The answer to this fundamental question must wait until we have discussed the relations of thinking to other organic processes and until we have discussed some of the important problems involved in these relations.

LECTURE II

Thinking and Other Organic Activities

We have seen from the point of view of the thinker that thought processes may arise from non-logical sources and may reach true conclusions in contravention of logical principles. But if the results of thought are to be of value to the thinker and to others it must square with the objective world, be consistent, and have some measure of practicality.

Abnormal Thinking

Abnormal thinking is characterized by failure of conclusions to fit the facts of the world outside the thinker. The two poles of abnormal thinking are the fixed idea held to regardless of reality and the flight of ideas running on without reference to concrete sign-posts. Dissociation from reality, either in premises or conclusions, may lead to fruitless thinking. Even the mathematician dealing with entities and operations having no reality in the usual sense is bound by the properties of the system in which he works and which is independent of himself once its properties are defined. Fruitful thinking must somehow refer to more than the operations and ideas of the thinker's mind. To train youth to think we try to arouse in them sentiments of truthfulness, consistency, and objectivity. Since sentiments are emotionally toned systems of ideas they represent the fusion of feeling and intellect. Feeling is the motor of thinking and without it little thinking is done. But the emotional part must be kept in proper proportion or thinking becomes so biased as to be dangerous. Thinking must be subjected to fact in all its aspects if it is to remain sane.

We have referred to the external world as the referent to which all thinking must point if it is to have validity and practicality. The external world must, however, not be thought of as a purely physical world for social stimuli are as real and important as physical. We are subject to stimulation from a wide variety of social stimuli such as other people, social organizations and other social products of all kinds. One of the most important social products influencing thinking is language, for by it the thoughts of others are conveyed to us and we express our thoughts to them. This brings us to the role of language in thinking.

Language and Thinking

The relation between language and thinking is so intimate that it has been taken as a criterion of the presence and quality of thought processes. The most radical theory of this relation was held by Max Mueller, famous Orientalist and scholar. He asserted that "Our divine reason is no more than human language." He went further in saying that "No reason without language, no language without words." According to his view we do not begin with thought and then proceed to speak but we begin with naming and then proceed to think. Members of widely different schools of psychology have held to similar views. Watson, leader of the behaviorists, believed that all thinking is really subvocal speech carried on by slight movements of the larynx. Washburn, a Titchenerian introspectionist in much of her work, regarded all associative processes as association between tentative or incipient movements of various bodily organs. Numerous experiments designed to test various forms of the motor nature of thinking have so far been inconclusive: some have asserted that all thought processes showed measurable movements in tongue, larynx, and even arm muscles; others have countered with evidence that an individual may be using these muscles while mentally solving problems concerned with other material at the same time. Perhaps the best criticism of these views comes from the field of animal experimentation. Animals which do not possess language nevertheless have been shown to solve problems requiring at least simple reasoning processes. Among human beings are many cases where something is known before the correct expression to communicate it is at hand. We conclude that while language is very necessary to thought the two are by no means identical.

Social Aspect of Thinking

The role of language in thinking is closely connected with the social nature of thinking because language is the result of social processes par excellence. One group of psychologists has given clear expression to the social nature of thinking in the following statement: "Everything we perceive is influenced . . . by what the society into which we are born has perceived and formulated into language symbols." The social nature of thinking is brought out very clearly also in the attempts of abnormal individuals to express their thoughts. Cameron has shown that patients suffering from senile dementia, a disease not forcing withdrawal from one's fellows, have entirely different

thought patterns from patients suffering from schizophrenia, a disease forcing withdrawal from society. The schizophrenic, according to Cameron, gives loose clusters of terms in attempting to answer a question, his idioms are highly personalized and with little meaning to others; the seniles, on the other hand, are definitely superior in the use of language and show remarkable preservation of social function up to advanced stages of deterioration. Here thought and social patterns betray remarkable similarities.

Thinking as Abstraction

The fact that so much of our thinking is socially conditioned means that there must be a certain economy in thought for social habits tend to represent what at a given time were easy ways for a folk. Since thinking deals with objects and events by representation, thought symbols are abstractions from the concrete reality. But if we take a character or property of an object to represent it we have transcended the object and are dealing with a class or a concept rather than with the specific object that first engaged our thinking. That our simplest activities involve abstraction has been shown by Dr. Kurt Goldstein, one of the most eminent neurologists who has investigated this aspect of thinking more than any other living being. He has told how patients, with frontal lobe injuries, have lost the power of abstraction and are reduced to the simplest forms of associative behavior wherein their every action depends upon concrete, visible objects to which they respond one at a time. The simplest task, such as placing two matches together to form an angle which they have just been shown, proves to be too much for them because this task already calls for more abstraction than they are capable of. To act in a world of relations means that we must somehow separate ourselves from concrete objects and Dr. Goldstein's patients demonstrate how necessary abstraction, or what he calls "categorical" behavior, is to meet even everyday problems.

Determinants and Signs of Thought Processes

If thinking is a central process as we earlier stated it to be, several questions immediately press for answer. What determines thinking in the organic set of events culminating in the thought process? Is thinking related to other psychological processes such as perception and emotion? Does thinking influence bodily processes and can it be detected from them?

In answer to the first question we find that due to the way in which events in the outer world make themselves known to us, our thinking about them must be closely related to the way we perceive, to the feelings and emotions they arouse in us, as well as to the dynamics governing central or brain processes. Stimuli affecting our sense organs give rise to chemical, photochemical, mechanical and electrical changes which are transmitted to the brain where they are represented by physico-chemical processes only now beginning to be understood. In the first instance our impressions are therefore determined by the nature of receptor and afferent activity. But before the highest nervous centers are reached neural impulses must pass through a region of the brain,

the diencephalon, where, according to the best evidence now obtainable, emotions are also generated. As a result all of our central processes are colored by feeling or emotional tone through the very nature of the system by which the thought processes are aroused. On the other side, thinking which presumably occurs in conjunction with cortical activity results in downward discharge through the diencephalon which in turn discharges impulses going to practically all organs of the body. For many years emotionally toned thoughts have been detected through the changes in perspiration (galvanic skin reflex), breathing rate, heart beat, and other bodily changes following emotional states. The correlation between bodily changes and either emotional or thought processes has not been good enough to initiate practical action, except perhaps in the case of the recent lie detectors which have achieved considerable accuracy and are being used in some courts of law. In lying there is a steady rise in blood pressure and there are changes in breathing which can be easily and reliably detected. In the light of known cortico-thalamic relations the influence of "mind over body" is no longer a matter of exaggerated claims or superstitions but perfectly reasonable and amenable to scientific investigation.

The most recent attempts to measure bodily signs of thought activities are found in the work of physiologists and psychologists who are concerned with "brain waves." Like every other organ of the body, the brain has associated with its activities minute changes in electrical potential which can be picked up, amplified and recorded. At least six different types of brain waves have been investigated in young and old, normal, feeble-minded, epileptic, and insane people, and during waking, sleeping, and hypnotic states. These studies are still in their beginnings and the picture they give us is by no means clear but the method has great promise as an objective approach to so-called subjective (central) processes. Its chief merit lies in the fact that brain waves can be obtained from individuals with no more trouble than fastening electrodes to the surface of the scalp.

Influence of Thinking on Organic Processes

With actual measurements being made in the laboratories of electrical changes in the brain, of changes in breathing, pulse, perspiration, surface temperature, digestion, and almost every other bodily process as a result of specific stimulation, it is not unreasonable to believe that central processes, whether or not they have definite peripheral antecedents, may arouse or modify organic activities. We found under laboratory conditions that mere anticipation of an electric shock was enough to cause a rise of several degrees of surface temperature with almost all subjects. Worry, fear, hope, regret, and other emotions may induce functional changes which in turn have organic effects if persisted in for a sufficient length of time. Since emotions and moods are accompanied by thought processes there is sound basis for the ancient dictum: "As a man thinketh, so is he."

LECTURE III

Types of Thinking and Their Explanation

The problem of thinking is bound up with questions concerning the role played by consciousness in organic activities. To those who have asserted that consciousness plays no part in the economy of living the obvious answer has been made that if this were true, consciousness, instead of becoming fuller and richer as organic forms evolve would have disappeared in the course of evolution. Thinking is that conscious process above all others that helps an organism to meet and solve problems. At different levels of activity the problems confronting an animal are different: an amoeba meets an object and either ingests or passes by it; a human being desires a job or wants to solve a problem in mathematics. Various tasks make various demands but not all demands can be said to involve thinking as we have defined it.

Thinking Versus Other Central Processes

If the problem demands merely recall of something experienced in the past only recognition and memory are involved, not thinking. If a lucky guess produces the correct solution thinking cannot be said to have occurred unless at a sub-conscious level but it is questionable if we should use the term thought for non-conscious cerebral processes. If every possibility is blindly tried without knowledge of its relevance to the problem, then we have so-called trial and error, a truly costly method in time, energy, and often of money as well. Thinking can be said to occur only when the demands and conditions of a problem are understood and then met. Thinking in this sense involves insight into the structure of the problem with an understanding of how the solution emerges from this structure.

Everyone has had the experience of trying to find a hidden face or figure in a picture without success until suddenly it pops out as of its own accord. The sudden emergence of the correct solution to a problem has been called "Aha" behavior because of the expression of surprise which so often accompanies such experiences. The re-structuration of central processes as one gropes for a solution manifests itself in overt behavior which even the uninitiated recognize as a flash of insight. The sudden change of behavior from blind, aimless activity to direct, sensible action can be seen very frequently in watching animals attempting to solve problems. Both Yerkes and Köhler have described such cases with chimpanzees and in everyday observation most of us have seen the quick change in behavior of our domestic pets when they have mastered a difficulty.

There are objective criteria of thinking which apply to animals as well as to humans so that we do not have to depend upon a "subjective" definition of thinking as a criterion of its existence. If the times or errors of successive trials at a task show a sudden drop from high scores to the lowest possible we have good mathematical evidence for insight into the nature of the problem. It is also possible to assess performance in objective terms by the degree to which it shows planning and direction. The animal that takes the shortest route to food in the face of barriers either by removing the obstructions or by going around them reveals understanding as we usually use this word.

Configurational Properties of Thinking

The view here proposed suggests that thinking is a structured, central process having a beginning, direction, and end. As such it may be said to be a temporal configuration. With von Ehrenfels we can say that configurations are wholes in which each part influences and is influenced by every other part. Such configurations have properties as wholes which their parts do not possess—in other words something new emerges. Furthermore, configurations are transposable, they do not depend upon any single set of elements for their properties. A melody can be transposed from one key to another, a joke can be translated into different languages. Changes in nuance occur with change in the elements, to be sure, but the general pattern is nevertheless preserved. Configurational structures also behave in characteristic ways as dynamic events: if incomplete, they tend toward closure; if unsymmetrical, they tend to become symmetrical; if subjected to external forces, they tend to be maintained by their internal forces.

The discerning will already have seen how thinking as we have treated it acts like a structured configuration. The thought process is aroused by some problem and presses for solution or closure. Once a thought-process is structured a certain way, it tends to continue in that way against outside forces. This explains the difficulty in divesting ourselves of a line of attack once we start with it to solve a problem. Thinking in its abstract features deals with whole properties or general features rather than with specific qualitative aspects. The same thought structure may arise from materially different problems and hence is transposable.

The configurational nature of thinking is not restricted to central processes alone. It springs from similar properties in perception. Our perceptions are of objects, structured unities created either by nature or by man. The emergence of a hidden face in a picture as a result of re-structuration is predominantly a perceptual affair, or can be made so by altering the stimulus appropriately. The dynamic properties of both physical and central physiological processes are found in perceptual acts as well. But emphasis on perceptual as against central processes is purely pragmatic, serving purposes of discussion, since peripheral and central processes are parts of a single neural system.

The configurational view of thinking here presented stresses insight rather than repetition in attempting to solve problems. It is also at variance with older views of thinking in other respects. Association instead of being a cause of structure-formation is rather a result of conditions favoring patterns just as the developer is a condition of a total picture. Past experience also ceases to play a fundamental role in solving problems since genuine solutions appear through closure of structures and not through accretion of ideas from past impressions. The problem of meaning receives new elucidation. Against the view that meanings are built up by the addition of sensations and images from past experiences to a kernel of sensory material furnished by the stimulus, the configurational view envisages meaning as arising from the differentiation of patterns out of simpler, homogeneous structures. Meaning thus becomes

intrinsic to structure and derivable from it rather than an addition of parts devoid of sense in themselves.

Some Practical Maxims of Thinking

From the position here taken many practical consequences follow, only a few of which can be indicated. Maxims of thinking and habit-formation, some of which we owe to Professor Max Wertheimer, founder of the Gestalt school of psychology, can be formulated as follows:

1. Approach new problems freshly and without bias of past experience. In this way the inhibiting effects and wrong steers from past experience are avoided.

2. See the structure or sense of the problem before attempting a solution. Once the structure is seen, thought-patterns are formed in accordance with the understanding of the problem and possibilities of closure (solution) then depend on the structure so formed. Grasp of the essential principle often obviates the necessity for trial and error and needless groping. A boy when told the principle governing balance experiences little difficulty in learning to ride a bicycle; without it he learns only after many falls.

3. Handle the situation or task as a whole, if possible; if not, handle the parts in the light of the end or goal to be reached. Successful designers, artists, scientists, composers, poets and other creative workers agree that the whole appears to them before the details. Often the "whole" may be only a vague, sketchy schema at first but it develops with thought. The meaning of *form* in sports, *rhythm* in dancing and in working, and *purpose* in life refer to properties of structured wholes governing part activities.

4. Rest, pause, deliberate in your efforts to reach ends, to achieve solutions. Not all accomplishment consists in a continual doing. Again creative workers report that flashes of insight, intuitions, solutions to problems come after intense concentration in moments of relaxation, or when engaged in some totally different activity from that demanded by the problem. The cult of continuous activity has forgotten the truth in William James' statement that "we learn to skate in summer and to swim in winter."

5. Having achieved a solution, inspect, revise, criticize it to be sure that it is correct. Among the criteria of intelligence is the capacity for self-criticism. The danger in accepting our own solutions lies in the fact that they are accompanied by feelings of satisfaction and resolution which are natural accompaniments of relief from tension. Satisfaction with a solution should not prevent us from verifying it later in as cold a mood as possible.

We have found that thinking is not a pale, emotionless intellectual activity. Rather it is filled with emotion which is its driving force. That the delights of thinking are as keen and invigorating as any experience ever can be, only those who have thought know.

The Wagner Free Institute of Science

BULLETIN

of the

WAGNER FREE INSTITUTE OF SCIENCE

PUBLISHED BY THE INSTITUTE

SYDNEY L. WRIGHT, *Editor*

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WAGNER FREE INSTITUTE OF SCIENCE

FACULTY

DAVID W. HORN, *Dean*
IVOR GRIFFITH, *Secretary*

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William B. Scott, A.M., Ph.D., LL.D., *Geology*
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Ivor Griffith, Ph.M., Sc.D., *Organic Chemistry*

Department of Geology and Paleontology

Benjamin F. Howell, A.M., Ph.D.

Carl Boyer, *Director*
John G. Hope, *Curator, absent on leave*

HISTORY

The Wagner Free Institute of Science was founded in 1847 by William Wagner, a citizen of Philadelphia.

In his early life William Wagner became associated with Stephen Girard in the extension of Girard's mercantile business. While in Girard's employ he had the opportunity to visit foreign countries, and being interested in scientific pursuits, he made a study of scientific institutions abroad and collected natural history specimens which afterward formed the nucleus for the collections in the museum of the Institute.

The Institute itself had its inception in a series of free lectures delivered by Professor Wagner in his home. These lectures, begun in 1847, were continued until 1855, when the Institute was incorporated by act of legislature.

A large measure of credit is due Mrs. Louisa Binney Wagner, Professor Wagner's wife, for sympathy, understanding and active coöperation in the early days of the founding of the Institute.

In 1855 a faculty was appointed and the work was continued in a new location at 13th and Spring Garden Streets, the City of Philadelphia giving permission for the use of Commissioners' Hall. Some years later Professor Wagner decided to erect a building on the present site at Seventeenth Street and Montgomery Avenue. This building was completed in 1865 and occupied immediately.

William Wagner died in 1885 and the management of the Institute was transferred to a Board of Trustees.

In 1901 a wing was added to the building for the use of a branch of the Free Library of Philadelphia.

INSTRUCTION

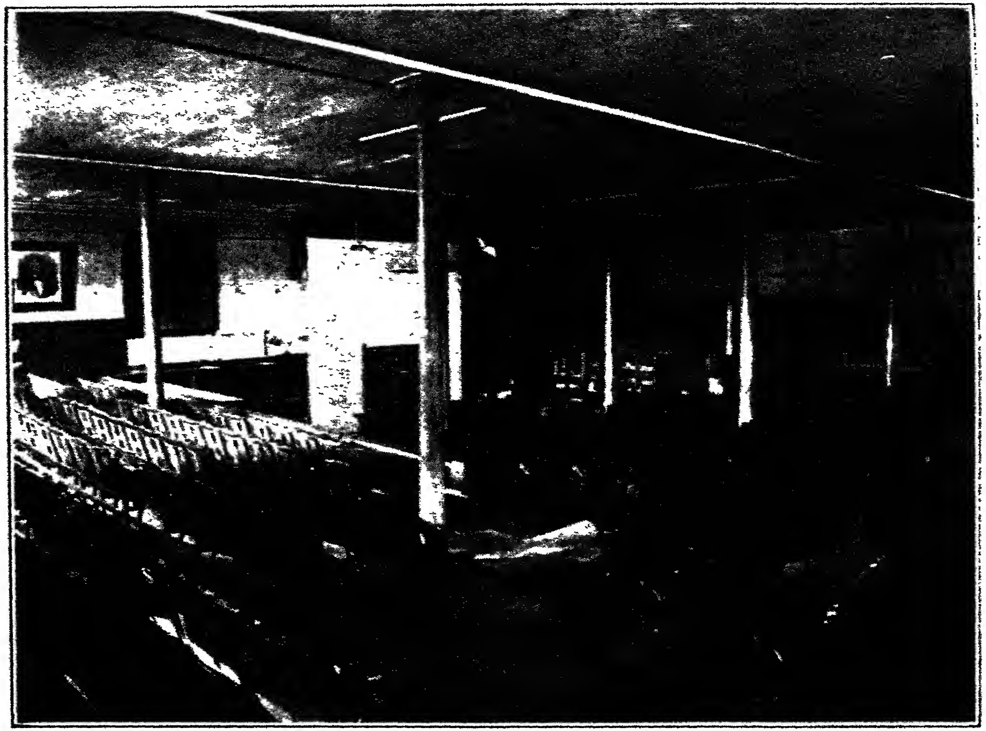
Lectures and Class Work

Instruction at the Wagner Free Institute of Science is conducted by means of lectures supplemented by class work. There are no tuition fees.

Persons may attend lectures without registering for the classes if they so desire. Those registering for the classes are required to hand in a weekly paper and are admitted to an examination at the end of the term. Those persons successfully passing the examination are awarded certificates for the year's work.

There are five courses of scientific lectures covering a period of fourteen weeks each for four years. On the successful completion of four years' work a Full Term Certificate is awarded.

The closing of each lecture season is marked by Commencement Exercises.



Auditorium

Museum

Museum

The Institute maintains a natural history museum containing more than 21,000 specimens illustrating the various branches of natural science.

The collections are arranged especially for study. The museum is open to visitors on Wednesday and Saturday afternoons from 2 P.M. until 5 P.M., except legal holidays.

Teachers and students desiring to use the museum for special studies will be admitted upon application at the office.

Libraries

The Reference Library of the Institute contains over 25,000 bound volumes and approximately 150,000 pamphlets on scientific subjects, classified and arranged for ready reference. There are also many foreign and domestic periodicals on file. The Library, formerly open daily (except Sundays and holidays), is now open to the public, as well as to students, on Monday, Wednesday and Friday from 2 P.M. to 9 P.M. and on Tuesday, Thursday and Saturday from 10 A.M. to 5 P.M. These hours will be continued for the duration.

The Free Library of Philadelphia maintains a branch library in the building, known as the Wagner Institute Branch, from which books may be taken out under the rules of the Free Library.

Publications

The publications of the Institute consist of three series:

Transactions: begun in 1885 and discontinued in 1927.

Publications: succeeding the Transactions. These Publications are issued at irregular intervals.

Bulletin: issued quarterly.

The Institute also publishes the Illustrated Catalog of North American Devonian Fossils, of which seven units have been issued to date.

Westbrook Free Lectureship

The Westbrook Free Lectureship is supported by the income from an endowment provided by Dr. Richard Brodhead Westbrook and his wife, Dr. Henrietta Payne Westbrook. The lectureship was established in 1912 and provides for one course of lectures each year. These lectures cover a wide range of topics and a list of those so far given may be found on page 34.

Fannie Frank Leffmann Memorial Lectureship

The income of a fund given by Dr. Henry Leffmann is applied to occasional special lectures under the Memorial Lectureship. These lectures are popular in character.

The *Philadelphia Natural History Society* is affiliated with the Institute and holds meetings at stated intervals.

RESEARCH

The Institute has carried on research work since 1885 in various departments of science. Results of research have been published from time to time in the Transactions, Publications and Bulletin.

The Institute is also the recipient of the income from two funds established by Dr. Henry Leffmann. This income is devoted to research in chemistry.

CERTIFICATES AWARDED AT CLOSING EXERCISES, MAY 19, 1943

FULL TERM CERTIFICATES

BOTANY

Agnes McFarland
Gertrude Vieweger

ORGANIC CHEMISTRY

Clarence Mosby

ENGINEERING

William H. Brown
William Heck
Homer J. Stineman

ZOOLOGY

Agnes McFarland

GEOLOGY

Clarence Strohm
Charles S. Thompson

Three Year Certificate in Botany

Frederick J. Duke

1942-43 CERTIFICATES AWARDED

BOTANY 4

Renaldo Di Stefano
Frederick J. Duke
Evelyn M. Fuller
Agnes McFarland
Gertrude Vieweger

INORGANIC CHEMISTRY 2

Adolph W. Awot
Theodore E. Cairns
Violette L. Edwards
Nicholas Helfrich
Eugene J. Kanin
Joseph Meuser, Jr.
John P. Roarty
Rudolph P. Meuser
Chester E. Myers
John Oshchypko

ORGANIC CHEMISTRY 2

Adolph W. Awot
Randall Bernstein
Harold H. Brehouse
Evelyn M. Fuller
Frances L. Getzman
John R. Landis
Pauline F. Wright
Vincent E. Latham
Clarence Mosby
Bernard Wagner

ENGINEERING 4

William H. Brown
Charles E. Clark
William Heck
Frederick Jackel, Jr.
Werner H. Schuele
William J. Schuele
Homer J. Stineman
Thom A. Street

ZOOLOGY 3

Agnes McFarland
Helen Ramsay
Mildred Ryder

GEOLOGY 4

Evelyn M. Fuller
Amanda M. Kessler
William J. Kiersznowski
Frank H. Moore, Jr.
Helen Ramsay
M. Dorothy Reed
Helen Shoemaker
Clarence Strohm
Charles S. Thompson

PHYSICS 1

Ralph Edwards
Evelyn M. Fuller
Frederick Jackel, Jr.
Joseph Meuser, Jr.
Rudolph P. Meuser
Chester E. Myers
Arthur G. Paul
George H. Shandle

FACULTY

JOHN WAGNER

B.S. in C.E., 1913, University of Pennsylvania.
C.E., 1920, University of Pennsylvania.
1913-1916, Draftsman, Phoenix Bridge Company.
1916-1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921-1926, Assistant Supervisor Track, Reading Company.
1926-1928, Supervisor Track, Reading Company.
1928-1930, Industrial Agent, Reading Company.
1930 to date, Assistant General Freight Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date.

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899-1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906-1915.
Head of Science Department, Germantown High School, 1915-1923.
Principal, Roxborough High School, 1923-1924.
Principal, Germantown High School, 1924-1943.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906-1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:

"Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
"Ether Waves and the Messages They Bring," Transactions of the Wagner Free Institute of Science.
"The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900-1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901-1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916-1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921-1937.
Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.
Dean of the Faculty.
Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Sc.D. (Hon.), Bucknell, 1934.
Editor, American Journal of Pharmacy, 1921-1941.
Dean of Pharmacy, Philadelphia College of Pharmacy and Science, 1938-1940.

President, Philadelphia College of Pharmacy and Science.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Fellow of the Royal Society of Arts, London, Eng.
Member American Chemical Society.
Member American Pharmaceutical Association.
Member Penna. State Board of Health.
Publications:
"Recent Remedies," 1926 (revised 1928). International Publications, N. Y.
"Popular Science Lectures," 14 volumes (Editor). Phila. College of Pharmacy and Science, Phila.
U. S. Dispensatory (Collab. Editor), Lippincott, Phila.
Formula Book, A. Ph.A. (Editor), Lippincott, Phila.
A Science Miscellany, International Printing Company, Phila.
Contributor to current chemical, pharmaceutical and medical literature.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology and Stratigraphy in Princeton University.
Lecturer on Paleontology and Geology, University of Pennsylvania.
Acting Curator, Department of Paleontology, Academy of Natural Sciences of Philadelphia.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Secretary of the International Paleontological Union.
Editor of the section of General Paleozoology of *Biological Abstracts.*
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, Colorado School of Mines, as a consulting paleontologist and research associate.

ANNOUNCEMENT OF REGULAR LECTURES, SESSION OF 1943–1944

ORGANIC CHEMISTRY 3

PROFESSOR GRIFFITH

Cyclic Hydrocarbons

Lectures begin at 8 P. M.

1. Monday, September 13.
   Destructive Distillation. Fractional Distillation. Coal tar (the ugly duckling of organic chemistry), wood tar; their industrial production and general uses.
2. Monday, September 20.
   The Genealogic Table of Old King "Coal." Fractionating coal tar. Commercial products light oil, dead oil, heavy oil, anthracene oil.
3. Monday, September 27.
   Benzene and its Homologues. Kekulé and his one-ring circus. Theories of molecular structure of cyclic hydrocarbons.
4. Monday, October 4.
   Derivatives of Benzene. Aromatic aldehydes. Solvents in this group and their war-time significance.
5. Monday, October 11.
   Derivatives of Benzene (Continued). Aromatic acids, benzoic, salicylic, etc.
6. Monday, October 18.
   Derivatives of Benzene (Concluded). Phenols: Phenol, cresol, resorcinol, pyrogallol.
7. Monday, October 25.
   Synthetic Medicines from Coal Tar. The fever chasers: Acetanilid, phenacetin, antipyrin.
8. Monday, November 1.
   Synthetic Medicines from Coal Tar (Concluded). The sleep coaxers and germ killers: Barbital and its compounds. The sulfa-drugs.
9. Monday, November 8.
   The Nitrogen Branch of the Coal Tar Family. Anilin—its homologues and derivatives, pyridin and quinolin. Nitrobenzene.
10. Monday, November 15.
    The Rainbow in a Barrel. Dyes from Coal Tar. Chemistry and Color. Perkins and his epoch-making mistake. Classification and general uses.
11. Monday, November 22.
    Dyes from Coal Tar (Continued). Color and chemical constitution. Coal tar dyes in the textile industries. The rise of the new American dyestuffs industry. Tricks of the German Cartel.
12. Monday, November 29.
    Dyes from Coal Tar (Continued). Theories of dyeing. The practice of dyeing. Newer advances in the dyeing art.
13. Monday, December 6.
    Dyes from Coal Tar (Continued). Dyes as indicators and laboratory stains. Dyes in disease. Dyes in the paint and lacquer industry.
14. Monday, December 13.
    Dyes from Coal Tar (Concluded). Uses in food-stuffs. Certified dyes. Detection and distinction from natural colors.

INORGANIC CHEMISTRY 3

PROFESSOR HORN

Descriptive Chemistry

Lectures begin at 7.45 P. M.

1. Tuesday, September 14.
   Carbon. The carbon cycle. Natural products: natural gas, petroleum, asphaltum, lignite, coal, diamond, graphite. Industrial products: charcoal, wood tar, bone oil, coke, diamond, graphite. Allotropy. Adsorption. Catalysis. Binary compounds: carbides, borides, silicides, sulphides, chlorides, fluorides. (Typical member, Periodic Group IV.)

2. Tuesday, September 21.
   Carbon (Continued). The oxides. Reducing action. Carbonate rocks. Hydrides of carbon: industrial fuel gases, gas engines. Carbon-nitrogen compounds: cyanides, cyanates, cyanamides.

3. Tuesday, September 28.
   Titanium, Zirconium, Hafnium, and Thorium. General outline: history, occurrence, preparation, properties, compounds, alloys, uses, detection. Special topics: prediction of Element 72, search for and isolation of Hafnium. (Members, Periodic Group IV, B Series.)

4. Tuesday, October 5.
   Silicon and Germanium. General outline: as in Lecture 3. Special topics: silicate minerals, sols and gels, pottery, glass, base-exchangers, fused quartz, silanes, germanes, prediction of Eka-silicon. (Members, Periodic Group IV, A Series.)

   Tuesday, October 12. (No Lecture.)

5. Tuesday, October 19.
   Tin and Lead. General outline: as in Lecture 3. Special topics: metallurgy, liquation, plated metals, cupellation, fire assay, estimates of age of minerals, storage batteries, amphoteres, basic salts, toxicity of lead. (Members, Periodic Group IV, A Series.)

6. Tuesday, October 26.
   Aluminum. General outline: as in Lecture 3. Special topics: Minerals, clays, emery, real and artificial gems, alums, mordants, lakes. Goldschmidt's process. (Member, Periodic Group III, A Series.)

7. Tuesday, November 2.
   Gallium, Indium, and Thallium. General outline: as in Lecture 3. Special topics: prediction of Eka-aluminium, analytical discovery of Indium, spectroscopic discovery of thallium. (Members, Periodic Group III, A Series.)

8. Tuesday, November 9.
   The Rare Earths. General outline: as in Lecture 3. Special topics: fractional crystallization, separations by basicity, atomic structure, isotopes, radioactivity, "mischmetall." (Members, Periodic Group III, B Series.)

9. Tuesday, November 16.
   Calcium. General outline: as in Lecture 3. Special topics: limestone, marble, lime, mortar, cement, plaster of Paris, phosphate rock, bones, teeth, super-phosphate fertilizer. (Member, Periodic Group II, A Series.)

10. Tuesday, November 23.
    Beryllium, Strontium, Barium, and Radium. General outline: as in Lecture 3. Jewels, glucinum, pyrotechnics, fixed white, lithopone, chemistry of radioactive elements, radioactive spring waters. (Members, Periodic Group II, A Series.)

11. Tuesday, November 30.

Magnesium and Cadmium. General outline: as in Lecture 3. Special topics: dolomites, modern methods of metallurgy of magnesium, fusible metal and eutectics, toxicity of cadmium. (Members, Periodic Group II, Magnesium in A Series, Cadmium in B Series.)

12. Tuesday, December 7.

Zinc and Mercury. General outline: as in Lecture 3. Special topics: Zinc couples, supercomplexes, intermetallic compounds, amalgams, transition points in metals, toxicity of mercury. (Members, Periodic Group II, B Series.)

13. Tuesday, December 14.

Lithium and Sodium. General outline as in Lecture 3. Special topics: lithia waters, Chile saltpetre, baking powders, fire extinguishers, "fixed alkalis." (Members, Periodic Group I, A Series.)

14. Tuesday, December 21.

Potassium, Rubidium, Caesium, and Virginium. General outline: as in Lecture 3. Special topics: causticizing, the Stasfurt deposits, potash in fertilizers, hydrolysis, Bunsen's spectroscopy. (Members, Periodic Group I, A Series.)

ENGINEERING 1

PROFESSOR WAGNER

Materials of Engineering Construction

Lectures begin at 7.45 P. M.

1. Friday, September 17.

Properties of Engineering Materials. Force. Stresses. Properties. Testing machines.

2. Friday, September 24.

Stone. Classification. Composition. Physical properties. Unit stresses.

3. Friday, October 1.

Brick. Composition. Manufacture. Physical properties. Special uses.

4. Friday, October 8.

Lime and Cements. Composition and manufacture of lime and its uses. Classification. Manufacture. Physical properties. Tests and uses of cements.

5. Friday, October 15.

Mortar and Concrete. Sand. Lime mortar. Cement mortar. Grout. Strength. Uses.

6. Friday, October 22.

Concrete and Mastics. Concrete: proportions, mixing, consistency, placing, and surface finish. Reinforced concrete: strength, uses. Mastics: composition, occurrences in nature, uses.

7. Friday, October 29.

Wood. The tree. Composition. Cell structure. Classification. Preparation for the market.

8. Friday, November 5.

Wood (Continued). Seasoning, shrinkage. Durability. Enemies of wood. Preservation processes. Physical properties and unit stresses.

9. Friday, November 12.

Cast Iron. Ores of iron. Occurrence in nature. Construction of the blast furnace. Metallurgy of the blast furnace. Physical properties and uses.

10. Friday, November 19.
    Wrought Iron. Chemical and physical composition. The puddle furnace. Physical properties. Unit stresses.
11. Friday, November 26.
    Steel. Definition. Alloys with carbon, nickel and chromium. Processes of manufacture. Recarbonization of wrought iron.
12. Friday, December 3.
    Steel (Continued). Gas producers and their construction. Open hearth process.
13. Friday, December 10.
    Steel (Concluded). Bessemer process and its limitations. Physical properties, strength, and unit stresses of structural steel.
14. Friday, December 17.
    Paints. Corrosion of iron and steel. Composition of paints. Theory and application.

GEOLOGY 1

PROFESSOR HOWELL

Physical Geography

Lectures begin at 7.45 P. M.

1. Monday, January 3.
   The Earth as a Planet. Its form, composition, and motion.
2. Monday, January 10.
   Atmosphere and Weather. How weather influences human activity and well-being.
3. Monday, January 17.
   Oceans. Tides, currents, epicontinental seas, and deeps.
4. Monday, January 24.
   Continents. Shields, plains, plateaus, and mountain ranges.
5. Monday, January 31.
   Islands. Island arcs, volcanic islands, and coral atolls.
6. Monday, February 7.
   Lakes and Rivers. River systems, ponds, lakes, and inland seas.
7. Monday, February 14.
   North America. Mexico, the United States, Canada, Alaska, and the Arctic islands.
8. Monday, February 21.
   Middle America. Central America and the West Indies.
9. Monday, February 28.
   South America. The Andes, the Guiana Shield, the Amazon Basin, the Pampas, and the Patagonian plains.
10. Monday, March 6.
    Europe. Its many peninsulas and the great Russian plains.
11. Monday, March 13.
    Asia. The Siberian tundra and taiga, the desert belt, the great mountain ranges, and the southern peninsulas.

12. Monday, March 20.
Africa. The Sahara Desert, the Congo Basin, the plateau regions, the eastern lowlands, and Madagascar.

13. Monday, March 27.
Australia. The eastern mountains, the great plains, and the western desert.

14. Monday, April 3.
The Pacific Islands and Antarctica. Japan, the Philippines, the East Indies, Oceanica, New Zealand, and the Antarctic continent.

Field Trip

If conditions permit, the class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the impossibility of arranging a schedule in advance, details of time and place will be announced later.

PHYSICS 2

PROFESSOR SEELY

Heat and Sound

Heat

1. Wednesday, January 5.
Energy shows itself only through matter. Vibrations in matter. Energy in atoms, in molecules, and in masses of matter. Changes in (a) temperature, (b) volume, (c) molecular arrangement.

2. Wednesday, January 12.
Heat energy causes changes in temperature. Temperature sensation. Temperature measurements. Thermometers and thermometer scales.

3. Wednesday, January 19.
Heat energy causes changes in volume. Coefficient of linear expansion. Charles' Law. The absolute zero. Illustrations and applications to building, refrigeration, etc.

4. Wednesday, January 26.
Heat energy causes changes in molecular structure. Latent heat of fusion. Specific heat. Applications to weather and climate.

5. Wednesday, February 2.
How heat energy travels from place to place. Conduction, convection and radiation. Radiant energy. Infra-red and ultra-violet waves. The solar constant.

6. Wednesday, February 9.
Heat energy may be measured. The Calorie and the British Thermal Unit. Transformation of energy and heat losses. The Joule.

7. Wednesday, February 16.
The mechanical energy equivalent of heat. Mechanical equivalent of heat. The laws of thermodynamics.

Sound

8. Wednesday, February 23.
Vibrating bodies resting in a fluid tend to produce waves. Vibrating bodies. Simple harmonic motion. Transverse and longitudinal waves.

9. Wednesday, March 1.
Air waves are the cause of sound sensation. Perception of sound. The ear. Limits of human hearing. Noise and hearing.

10. Wednesday, March 8.

Sound waves have certain properties and behave in certain ways. Velocity. Reflection. Echoes. Whispering galleries. Resonance.

11. Wednesday, March 15.

Properties and behavior of sound waves (Concluded). Sympathetic vibrations. Interference. Beats. Harmony and discord.

12. Wednesday, March 22.

Musical sounds are those which are pleasing to the ear. Pitch. Intensity or loudness. Quality or timbre. Doppler's principle. Overtones. Resonators.

13. Wednesday, March 29.

Musical sounds (Concluded). The musical scale. Melody, harmony and rhythm.

14. Wednesday, April 5.

Man has made and studied many musical instruments. Laws of vibrating strings. Nodes and segments. Vibrating columns of air.

GENERAL SCHEDULE OF REGULAR LECTURES

Subjects of courses in each of the four successive years constituting a full term.

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles and Theories. Notation. Non-Metals.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

LECTURES UNDER RICHARD B. WESTBROOK FOUNDATION

1912.—Ancient Civilization of Babylonia and Assyria. *Morris Jastrow, Jr., Ph.D.*

1913.—Conservation of Natural Resources.
Gifford Pinchot, Marshall O. Leighton, Overton W. Price, Joseph A. Holmes.

1914.—The Theory of Evolution. *William Berryman Scott, Ph.D., LL.D.*

1915.—Invisible Light. *Robert Williams Wood, LL.D.*

1916.—Aspects of Modern Astronomy. *John Anthony Miller, A.B., A.M., Ph.D.*

1917.—Heredity and Evolution in the Simplest Organisms.
H. S. Jennings, B.S., A.M., Ph.D., LL.D.

1918.—The Chemistry, Nutritive Value and Economy of Foods.
Harvey W. Wiley, A.M., M.D., B.S., Ph.D., LL.D., D.Sc.

1919.—The Origin and Antiquity of the American Indian.
Aleš Hrdlička, M.D., Sc.D.

1920.—Chemistry and Civilization. *Allerton S. Cushman, B.S., A.M., Ph.D.*

1921.—Microbiology. *Joseph McFarland, M.D., Sc.D.*

1922.—Evolution of the Human Face. *William K. Gregory, Ph.D.*

1923.—The Philosophy of Sanitation. *George C. Whipple, B.S.*

1924.—The Distribution of American Indian Traits. *Clark Wissler, A.M., Ph.D.*

1925.—Structural Colors. *Wilder D. Bancroft, Ph.D., Sc.D.*

1926.—The Animal Mind; its sources and evolution. *George Howard Parker, Sc.D.*

1927.—An Interpretation of Atlantic Coast Scenery. *Douglas W. Johnson, Ph.D.*

1928.—The Science of Musical Sounds. *Dayton C. Miller, Ph.D.*

1929.—Volcanoes and Vulcanism. *William B. Scott, Ph.D., LL.D.*

1930.—Present Problems of Evolution. *Edwin Grant Conklin, Ph.D., Sc.D., LL.D.*

1931.—The Problems of the Origin and Antiquity of the American Aborigines in the Light of Recent Explorations. *Aleš Hrdlička, M.D., Sc.D.*

1932.—Common Sense, Science and Philosophy. *John Dewey, Ph.D., LL.D.*

1933.—Social Relations in Monkey, Ape and Man.
Robert M. Yerkes, A.M., Ph.D., Sc.D.

1934.—Chemistry and Industrial Progress as Exemplified in the Study of Hydrogen and Oxygen. *Hugh S. Taylor, D.Sc., F.R.S.*

1935.—Recent Progress in Astronomy. *Samuel A. Mitchell, M.A., Ph.D., LL.D.*

1936.—Real Lilliputians of the Universe. *Ellis L. Manning.*

1937.—Biology and Social Problems. *Edwin Grant Conklin, Ph.D., Sc.D., LL.D.*

1938.—Emotions and the Social Order. *Frederick H. Lund, A.M., Ph.D.*

1939.—The Making and Mixing of Human Races.
Earnest A. Hooton, Ph.D., B.Litt., Sc.D.

1940.—Atomic Nuclei and Atomic Transmutations.
Kenneth T. Bainbridge, S.M., Ph.D.

1941.—Geography and Its Influence on History. *Derwent Whittlesey, Ph.D.*

1942.—From Nature Through the Test Tube to Textiles and Plastics.
Jesse W. Stillman, A.M., Ph.D.

1943.—Thinking: Some Problems and Solutions. *Harry Helson, A.M., Ph.D.*

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NEW RECORDS OF RECEPTACULITIDAE FROM THE MISSISSIPPI VALLEY

By

BENJAMIN F. HOWELL, A.M., PH.D.

A receptaculitid from the paleontological collection of the University of Iowa, which was found in the Niagaran Silurian Gower Formation of Iowa and submitted to the writer for identification, has proved to be an example of *Ischadites infundibulum* (Hall). As this appears to be the first discovery of this species in the Gower Formation and in the State of Iowa, it is worthy of record. And since the specimens on which Hall based his original description of this species have never been figured from photographs, this opportunity is taken to present such figures of them.

There are in the paleontological collection of Princeton University three specimens of *Ischadites ohioensis* from Cedarville, Greene County, Ohio. As this species appears not to have been reported from Cedarville nor to have been figured by photography, photographic illustrations of these specimens are likewise published here. Photographic reproductions of two other receptaculitids, *Ischadites reticulatus* (Owen) and *Cerionites dactyloides* (Owen), which seem not to have been figured from photographs and which are represented by good specimens in the Princeton collection, are also included. Comments are added concerning the generic references of all these species, about which there has been much difference of opinion among authors who have discussed or listed American Receptaculitidae.

Ischadites infundibulum (Hall)

Figs. 1, 2.

Receptaculites infundibulum Hall, Rept. of Superintendent of Geol. Surv. Wisconsin, 1861, p. 16.

Receptaculites infundibulus Hall, 20th Rept., New York State Cabinet of Nat. Hist., 1867, pp. 390, 395.

Receptaculites infundibulus Hall, 20th Rept., New York State Cabinet of Nat Hist., revised edit., 1870, p. 435.

Receptaculites formosus Meek and Worthen, Proc. Acad. Nat. Sci. Philadelphia, 1870, pp. 22, 23.

Receptaculites formosus Meek and Worthen, Geol. Surv. Illinois, vol. 6, 1875, p. 500, pl. 24, fig. 1.

Ischadites tessellatus Hinde, Quart. Jour. Geol. Soc. London, vol. 40, 1884, p. 839.

Ischadites tessellatus Winchell and Schuchert, Geology of Minnesota, vol. 3, pt. 1, 1895, p. 66.

Receptaculites infundibulum Whitfield, Amer. Mus. Nat. Hist., Mem. 1, pt. 2, 1895, p. 46, pl. 5, figs. 1, 2.

Receptaculites tessellatus Bassler, U. S. Nat. Mus. Bull. 92, vol. 2, 1915, p. 1098.

James Hall's failure to publish a figure of his "*Receptaculites infundibulum*" with his original, 1861, description led to that species being described in 1865 under a different specific name, *tessellatus*, by Winchell and Marcy and to Hinde's and most other later authors' acceptance of the latter name, although Hall in 1867 called attention to the fact that it was a synonym. Hall's description, which was quoted by Whitfield in 1895, was sufficiently full to validate his name; and Whitfield's republication of it with figures of two of Hall's cotypes made both description and illustrations easily available to students.

One of Hall's cotypes, which is refigured in the present paper, is No. 1973 in the Hall Collection of the American Museum of Natural History. It is from the Niagaran Silurian Racine Formation at Racine, Wisconsin, and is refigured here through the courtesy of Dr. H. E. Vokes and Mr. Berthold F. Zellner. Six other specimens, some of them fragments of individuals of larger size than the one figured here, are also included in the Museum's Hall collection. All of them are from Niagaran beds at Racine, and all were probably used by Hall in preparing his description of the species. The cotype figured is believed to be one of those figured by Whitfield in 1895 (Amer. Mus. Nat. Hist., Mem. 1, pt. 2, pl. 5, fig. 1).

The specimen from the Gower Formation (which is also of Niagaran age) that is figured in the present paper is from SW ¼ sec. 10, Wyoming Township, Jones County, Iowa. It is 717 in the paleontological collection of the University of Iowa, and is here figured and discussed through the courtesy of Professor A. K. Miller of that university.

The condition of fossilization of this Gower specimen is such that nothing can be learned about its internal structure. It is referred in the present paper to the genus *Ischadites* because the species to which it appears to belong has been placed by Hinde and by Winchell and Schuchert, who made special studies of the Receptaculitidae, in that genus.

Winchell and Schuchert (Geology of Minnesota, vol. 3, pt. 1, 1895, p. 66) call attention to the fact that the receptaculitid which was described by Billings as *Ischadites canadensis* (Geology of Canada, 1863, p. 300, fig. 313, and p. 327) may be identical with *Ischadites infundibulum* (Hall). *Ischadites canadensis* was described by Billings from Niagaran beds in the Township of

Esquesing, Ontario. Billings' description was based on a single fragmentary specimen. No record of the discovery of additional specimens has been published, and Miss Alice Wilson, of the Canadian National Museum, and Miss Madeleine Fritz, of the Royal Ontario Museum, have informed the writer that no other examples of the species are preserved in their museums. Whether Billings' species is identical with Hall's can probably not be determined until additional and more complete examples of *canadensis* have been discovered. Canadian collectors should attempt to find such specimens so that this question can be answered.

Ischadites ohioensis (Hall and Whitfield)
Figs. 3, 5, 6

Receptaculites Ohioensis Hall and Whitfield, Geol. Surv. of Ohio, vol. 2, pt. 2, 1875, p. 123, pl. 6, fig. 1.
Ischadites hoenigii (part) Hinde, Quart. Jour. Geol. Soc. London, vol. 40, 1884, p. 836.

It is possible that this species should be placed in *Receptaculites*, rather than in *Ischadites*. Hinde, however, believed not only that it was referable to *Ischadites*, but that it was identical with the species which Sir Roderick Murchison had described in 1839 from Upper Silurian Ludlow beds in Wales as *Ischadites königii* (Silurian System, 1839, pp. 697–698, pl. 26, fig. 11). Winchell and Schuchert (Geology of Minnesota, vol. 3, pt. 1, 1895, p. 65) pointed out specific differences between *königii* and *ohioensis*, but appear to have agreed with Hinde that *ohioensis* was an *Ischadites*.

The preservation of the four onomatype specimens of *ohioensis* from the Niagaran of Ohio which are preserved in the Princeton collection is such that nothing can be learned from them which would indicate to which of the two genera they belong. One of these specimens, a topotype (Princeton No. 5925), is from Yellow Springs, Ohio. The other three, figured here (Princeton Nos. 301 and 42744), are from Cedarville, Greene County, Ohio.

Ischadites reticulatus (Owen)
Fig. 7

Orbitulites? reticulata Owen, Rept., Geol. Exploration Iowa, Wisconsin, and Illinois, 1844, pp. 70, 86, pl. 18, fig. 7.
Selenoides iowensis Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, 1852, p. 587, pl. 2 B, fig. 13.
Receptaculites fungosum Hall, Rept., Prog. Geol. Surv. Wisconsin, 1861, p. 15.?
Receptaculites iowensis Billings, Palaeozoic Fossils, vol. 1, Geol. Surv. of Canada, 1865, pp. 385, 386, fig. 364.
Receptaculites iowensis Billings, Canadian Naturalist and Geologist, new series, vol. 2, 1865, pp. 191, 192, fig. 12.
Ischadites iowensis Winchell and Schuchert, Geology of Minnesota, vol. 3, pt. 2, 1895, pp. 64, 65, pl. F, figs. 5, 6.
Receptaculites fungosus Whitfield, Amer. Mus. Nat. Hist., Mem. 1, pt. 2, 1895, p. 44, pl. 5, figs. 5, 6.

Ischadites koenigii (part) Hinde, Quart. Jour. Geol. Soc. London, vol. 40, 1884, pp. 836, 837.
Ischadites iowensis Bassler, U. S. Nat. Mus. Bull. 92, vol. 2, 1915, p. 669.

David Dale Owen first brought this species to the attention of paleontologists when he published a description and figure in his "Report of a Geological Exploration of Part of Iowa, Wisconsin, and Illinois" in 1844. In the description and in the explanation of the plate on which the figure occurs the species is called by Owen "*Orbitulites? reticulata.*"

Eight years later Owen published another description and figure of this same species, using another name for it, *Solenoides iowensis*. This description and figure appeared in his "Report of a Geological Survey of Wisconsin, Iowa, and Minnesota," published in 1852 (p. 587, pl. 2 B, fig. 13). No reference to the 1844 figure of "*Orbitolites? reticulata*" is made in the 1852 description of *Selenoides iowensis*, the figure of *iowensis* which was published in 1852 was that of a different specimen from the one on which *reticulatus* was based, and *iowensis* was stated in the 1852 description to be a new species. Nevertheless, it seems reasonably certain that it and Owen's "1844 *Orbitolites reticulata*" were one and the same species, and that the correct specific name for that species is therefore *reticulatus*.

Had succeeding authors disregarded Owen's second specific name and used his first one, *reticulatus*, for his fossil, little harm would have been done. But they did not do this, but used his second name, *iowensis*. And, since the species has been frequently referred to in the literature, the incorrect name has become well known, while the correct one has been forgotten, and must now be resurrected practically "from the grave."

Owen's original, 1844, reference of his species to *Orbitulites* was obviously an error. His later, 1852, proposal of the new genus, *Selenoides*, for the same fossil was also not satisfactory, for Murchison had proposed in 1839 the genus *Ischadites* for a species, which he called *Ischadites königii*,* that is probably congeneric with Owen's species. Owen's fossil should therefore be called *Ischadites reticulatus*.

Various authors have assigned *reticulatus* to the genus *Receptaculites*.† The writer believes that the species is more probably referable to *Ischadites* because it has the combination of diagonally arranged and horizontally arranged reticulations characteristic of that genus (the horizontally arranged ones forming a band around the periphery as they do in such other species of *Ischadites* as *I. königii*, the genotype of *Ischadites*, and *I. ohioensis*), and because the body, as a whole, closely resembles in form the figure of *I. lindstroemi* Hinde, published by Hinde (Quart. Jour. Geol. Soc. London, vol. 40, 1884, pl. 36, fig. 2), while it differs in obvious ways from *Receptaculites neptuni* Defrance, the genotype of *Receptaculites*, and from such North American species usually referred to *Receptaculites* as *R. occidentalis* Salter and *R. oweni*

* The Silurian System, 1839, p. 697, pl. 26, fig. 11.

† See Bassler, R. S.: Bibliographic Index of American Ordovician and Silurian Fossils, U. S. National Museum Bulletin 92, pt. 1, 1915, p. 669.

Hall. Hinde (Quart. Jour. Geol. Soc. London, vol. 40, 1884, p. 836) considered it so similar to *Ischadites königii* as to be specifically identical with that species and Winchell and Schuchert (Geol. of Minnesota, vol. 3, pt. 2, 1895, p. 64) also placed it in the genus *Ischadites*. The writer has not been able to find any published record of the finding of an example of *reticulatus* that showed the one character which Hinde considered diagnostic of *Ischadites*—the absence of an inner layer of plates, such as is present in *Receptaculites*—and he himself has never seen a specimen of that species which displayed such a layer. He therefore considers the assignment of the species to *Ischadites* as not certainly, even though probably, correct.

Hinde (Quart. Jour. Geol. Soc. London, vol. 40, 1884, p. 815) states that *Ischadites* also differs from *Receptaculites* in having a "Conical or ovate form." *Ischadites königii*, the genotype, *does* have such a form. Our species, *reticulatus*, does *not*. It is possible that this and the other minor differences which distinguish it from *königii* are important enough to require our placing *reticulatus* in another genus or subgenus of its own, which would bear Owen's 1852 name, *Selenoides*. If future discoveries prove that this should be done, *Ischadites lindstroemi*, from the Silurian Wenlock Beds of Europe, will probably also have to be placed in the same genus or subgenus with it.

James Hall named in 1861 as *Receptaculites fungosum* and *Receptaculites globulare* certain fossils from the Middle Ordovician rocks of the Upper Mississippi Valley which some later authors have considered to be referable to our species (Rept., Geol. Surv. Wisconsin, 1861, pp. 15, 16). The specimens on which Hall based his two names were later figured by Whitfield (Amer. Mus. Nat. Hist., Mem. 1, pt. 2, 1895, pp. 44–46, pl. 5, figs. 5–7). They differ from a typical example of *reticulatus* in form, but may be aberrant individuals of that species. Whether they should be considered to be such, or whether they should be looked upon as distinct species or varieties, can be determined only when enough examples of such fossils have been collected to prove whether or not individuals existed that were intermediate in shape between the three forms.

The specimen of *Ischadites reticulatus* which is figured in the present paper is No. 13 in the paleontological collection of Princeton University. It is from a Trentonian Ordovician bed at Galena, Illinois. Another specimen, from Trentonian beds at Menominee, Jo Davis County, Illinois, is No. 5981 in the paleontological collection of the Wagner Free Institute of Science.

Cerionites dactioloides (Owen)

Figs. 4, 8, 9

Lunulites? dactioloides Owen, Rept., Geol. Exploration Iowa, Wisconsin, and Illinois, 1844, pp. 69, 76, pl. 13, fig. 4.

Pasceolus? (Cerionites) dactylioides Meek and Worthen, Geol. Surv. Illinois, vol. 3, 1868, pp. 345, 346, pl. 5, figs. 2 a-c.

Lunulites dactylioides Kayser, Zeits. d.d. geol. Gesell., vol. 27, 1875, p. 780.

Cerionites dactyloides Whitfield, Geology of Wisconsin, vol. 4, 1882, pp. 267–269.

Cerionites dactiloides Whitfield, Geology of Wisconsin, Vol. 4, 1882, pl. 13, figs. 1–3.
Cerionites dactylioides Calvin, American Geologist, vol. 12, 1893, pp. 53–57.
Cerionites dactylioides Winchell and Schuchert, Geology of Minnesota, vol. 3, pt. 2, 1895, pp. 67, 68.
Cerionites dactyloides Bassler, U. S. Nat. Mus. Bull. 92, vol. 2, 1915, p. 204.

When Owen first described and named this species in 1844 he assigned it doubtfully to the genus *Lunulites* and spelled the specific name "*dactioloides.*"* Twenty-eight years later Meek and Worthen pointed out that it could not be a *Lunulites*. They thought it might be referable to Billings' genus, *Pasceolus;* but they were not sure about that, and they suggested the new genus, *Cerionites*, for it in case it proved not to have been properly placed in *Pasceolus*. They misspelled the specific name "*dactylioides.*" Seven years later Kayser, in a discussion of the genus *Pasceolus*, decided that this species could not belong in that genus. He also misspelled the specific name, "*dactylioides*," as Meek and Worthen had done. In 1882 Whitfield discussed the species at length and concluded that it was not referable to *Pasceolus*, and that Meek and Worthen's suggested genus, *Cerionites*, should be adopted for it. Whitfield spelled the specific name "*dactyloides*" in the text of his paper and "*dactiloides*" in the explanation of his figures.

In 1893 Calvin published a paper, "On the Structure and Probable Affinities of *Cerionites dactylioides* Owen." He argued that the specific name should be spelled "*dactylioides*," and concluded that *Cerionites* was a genus of colonial Protozoa. His discussion of the genus is the most complete one yet published; but his arguments for the protozoan nature of *Cerionites* are not very convincing, and the relationships of the genus are still in doubt.

The International Rules of Zoological Nomenclature would appear to require that Owen's original spelling of the specific name of this species should stand, and that the fossil should be called *Cerionites dactioloides*. There seems to be no justification under the rules for altering Owen's spelling.

But a satisfactory decision on the relationships of the genus *Cerionites* is much more difficult to reach. Kummerow† has recently described from boulders of Ordovician limestone left by Pleistocene glaciers in northern Germany examples of two species of *Apidium* (a genus which in some respects resembles *Cerionites*, although it differs in other ways) that seem to him to present evidence that *Apidium* is a genus of calcareous algae. He has noted that *Apidium* is related to *Cyclocrinus*, a genus to which Stolley in 1896 (Archiv für Anthropologie und Geologie Schleswig-Holsteins, Bd. 1, Heft 2, 1896, p. 215) had assigned Owen's species. American paleontologists remain doubtful as to the relationships of *Cerionites;* and their cautious attitude is

* For bibliographic references of this and succeeding citations see the synonomy of this species, above.

† Kummerow, E.: Die Bruteinrichtungen pälozoischer Ostracoden, sowie über *Receptaculites* und einige ordovizische Kalkalgen der Gattung *Apidium*. Jahrbuch der Preussischen Geologischen Landesanstalt für 1936, Band 37, 1937, pp. 465–474, pl. 21.

probably correct, for really convincing evidence of its systematic position is still lacking. It may be referable to the Receptaculitidae, and it may be assignable to the sponges; but it is possible that it will prove, when it is better known, to belong to some other group of animals or to the calcareous algae.

The two specimens of *Cerionites dactioloides* in the Princeton collection do not add to our knowledge of the anatomy of the species, although they illustrate the two forms of preservation in which the species commonly occurs —that in which the outer surface is covered with shallow hexagonal pits, and that in which the outer layer of such pits is lost and the surface of the fossil is a mass of hexagonal prisms.

The Princeton specimens are onomatypes, Nos. 53443 and 53444, from the Niagaran Silurian Hopkinton Formation of Jackson County, Iowa. The species is said to be common in the Hopkinton Beds of that county.*

The writer wishes to record here his gratitude to Dr. E. O. Ulrich and Dr. R. S. Bassler for information concerning the species *iowensis* and *ohioensis*, which they kindly gave to him during the writing of this paper. He also wishes to thank Professor A. K. Miller for permitting him to figure and discuss the specimen of *Ischadites infundibulum* from Iowa and Dr. H. E. Vokes and Mr. Berthold F. Zellner for making it possible for him to examine and figure Hall's type specimens of that species.

* See Savage, T. E.: Geology of Jackson County. Iowa Geological Survey, Annual Report for 1905; 1906, pp. 563-648 (Reference on p. 616).

Explanation of Plate

Fig. 1: *Ischadites infundibulum* (Hall). XI. No. 717, Univ. of Iowa. Gower Formation, Niagaran, Middle Silurian. SW ¼ sec. 10, Wyoming Township, Jones County, Iowa.

Fig. 2: *Ischadites infundibulum* (Hall). Cotype. XI. No. 1973, Hall collection, Amer. Mus. Nat. Hist. Racine Formation, Niagaran, Middle Silurian, Racine, Wisconsin.

Fig. 3: *Ischadites ohioensis* (Hall and Whitfield). XI. No. 42744, Princeton Univ. Niagaran. Middle Silurian. Cedarville, Greene County, Ohio.

Fig. 4: *Cerionites dactioloides* (Owen). XI. No. 53443, Princeton Univ. Hopkinton Formation, Niagaran, Middle Silurian. Jackson County, Iowa.

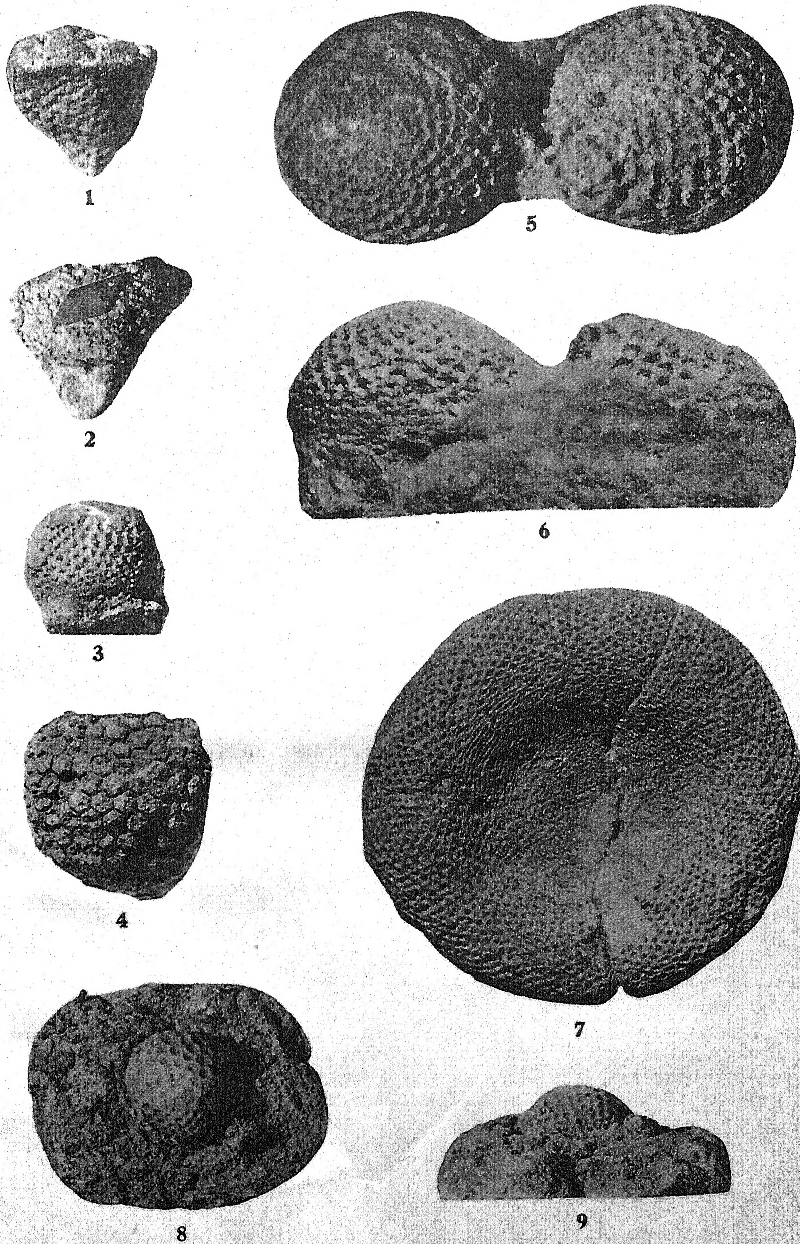
Fig. 5: *Ischadites ohioensis* (Hall and Whitfield). Top view of two specimens. XI. No. 301, Princeton University. Niagaran, Middle Silurian. Cedarville, Greene County, Ohio.

Fig. 6: The same, side view.

Fig. 7: *Ischadites reticulatus* (Owen). Top view. XI. No. 13, Princeton Univ. Trentonian, Middle Ordovician. Galena, Illinois.

Fig. 8: *Cerionites dactioloides* (Owen). Top view. XI. No. 53444, Princeton Univ. Hopkinton Formation, Niagaran, Middle Silurian. Jackson County, Iowa.

Fig. 9: The same, side view.



HOWELL– NEW RECORDS OF RECEPTACULITIDAE
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